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CALIBRATION SYSTEM FOR DUST SAMPLING.(U)
SEP 75 J YABLONSKY, H AYER, J SVETLIK DAMD17-74-C-4024

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July 19, 1976

Prof. Howard E. Ayer
University of Cincinnati Medical Center
Dept. of Environmental Health
Kettering Laboratory
3223 Eden Avenue
Cincinnati, Ohio 45267

Dear Prof. Ayer:

With reference to your letter of July 8, 1976, we hereby grant permission for you to reproduce Bulletin PD-8 (copyright 1974) for the sole purpose of inclusion in an instruction manual for apparatus containing Balston Series A filters.

Very truly yours,

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DEPARTMENT OF ENVIRONMENTAL HEALTH
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October 7, 1976

Mr. Charles E. Gould
Chief, Acquisition and Selection Branch
Defense Supply Agency
Defense Documentation Center
Cameron Station
Alexandria, Virginia 22314

Ref: DAMD17-74-C-4024 new

Reply Ref: DDC-TC

Dear Mr. Gould:

In response to your letter of 29 June 1976, I have enclosed reproducible pages as requested. They are as follows:

Appendix 1-A	Page 50	Drawing, Aerosol Chamber
Appendix 1-C	Page 52	Black & White Glossy
Copyright	Page 53	Approval Letter
Appendix 1-D	Page 54	Drawing, Fluiding Generator
	Page 61	Black & White Glossy
Appendix 11-A	Page 63	Black & White Glossy
Figure 1	Page 65	Black & White Glossy
Figure 2	Page 66	Black & White Glossy
Figures 3 & 4	Page 67	Black & White Glossy
Figures 5 & 6	Page 68	Black & White Glossy
Figures 22 & 23	Page 77	Black & White Glossy
Figures 24 & 25	Page 78	Black & White Glossy
Appendix 11-B	Pages 80-85,87	

Sincerely yours,

Howard Ayer

Howard E. Ayer
Professor of Environmental Health

HEA:hc

Enclosures (18)

cont.

yielded a maximum coefficient of variation of 7% with typical values of 2%. Samples from top ports averaged 95% of those from the side ports.

Utility of the chamber for field testing was demonstrated by showing that the performance of Aerotec "3/4" cyclones and Unico 240 cyclones, operated at their rated flows, varied significantly.

Size distributions, determined by an Andersen Sampler, were found to be approximately log-normal with the exception of the Nebulizer aerosol. The mass median diameter aerodynamic diameter was slightly greater in the lower portion of the chamber, confirming the settling of coarser dust suggested by the total mass concentrations from side ports being less than those from top ports.

Some deficiencies in ease of sampling resulted in an improved chamber design.

This report includes a complete description and detailed operating instructions as well as data and test results.

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

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Aerosol Chamber
Generation System
Calibration

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

An aerosol chamber was designed, constructed and tested with each of three aerosol generators. A Nebulizer was provided for liquid aerosols, A Wright Dust Feed for long-term dust generation, and a Fluidizing Generator for short duration, high concentration dust aerosols.

Uniformity of distribution of aerosol was tested with each of the three aerosol generating systems. Samples from side and top ports next page

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CALIBRATION SYSTEM FOR DUST SAMPLING

Final Report

Mr. Jack Yablonsky
Mr. Howard Ayer
Mr. Jozef Svetlik
Dr. Sanford Horstman

Supported by
U.S. Army Medical Research and Development Command
Washington, D.C. 20314

Contract No. DAMD17-74-C-4024
Department of Environmental Health
University of Cincinnati
Cincinnati, Ohio 45267

SUMMARY

An aerosol chamber was designed, constructed and tested with each of three aerosol generators. The chamber, cylindrical with a conical bottom section above an aerosol mixing section, had a volume of approximately 0.45 cubic meters. The chamber had 8 sampling ports on the top and 14 sampling ports on the side, permitting up to 22 samples of different types through the ports. A shielded strontium-90 source was contained in the aerosol supply line to electrically discharge the aerosol. Airflow through the chamber was provided by a centrifugal compressor and controlled by valves in the system. Exit air from the chamber was filtered before discharge.

Three aerosol generation systems were furnished. A nebulizer was provided for aerosols produced from liquid solutions, a Wright Dust Feed for long-term dust generation, and a fluidizing generator for shorter period, high level dust concentrations.

Uniformity of distribution of aerosol concentration throughout the chamber was tested by operating the chamber with aerosols generated by each of the systems. For samples collected from the side ports at 4.5 cm from the side wall, the maximum coefficient of variation (100X standard deviation/mean) was 7% with typical coefficients of variation of 2%. Samples from the top ports averaged 95% of those at the side, but coefficients of variation for top port samples were similar to those from the side ports.

In a demonstration of the utility of the chamber for testing field sampling equipment, a series of runs was made with two types of size-selective samplers for sampling "respirable" dust. Aerotec"3/4" cyclones operated at 25 liters/minute passed averages of 44%, 40%, 40% and 39%, respectively, in four runs. Unico 240 cyclones operated at 75 liters/minute passed averages of 57%, 54%, 54% and 58%, respectively, in the same four runs. Thus, it was demonstrated conclusively that at their rated flows, the performance of these two devices was significantly different.

Size distributions were determined by Andersen sampler for each run. It was found that the distribution of dusts generated was approximately log-normal, but the nebulizer does not produce an aerosol with a log-normal size distribution. The mass median aerodynamic diameter of dusts was slightly greater in the lower portion of the chamber, confirming the settling of coarser dust suggested by total mass concentrations from side ports being less than those from top ports.

Deficiencies noted in the aerosol chamber included the inability to conveniently place complete sampling devices inside the chamber for test, and a somewhat awkward situation for loading samplers from the top. Although opening and closing of the chamber top was made considerably easier when the initial stainless steel top was

replaced with a lighter gauge top, other problems remained.

To improve usability of the chamber while not disturbing its excellent aerosol mixing and aerosol cloud uniformity, a new chamber was ordered incorporating all the features of the chamber tested, with the addition of a side wall door, a removable grille inside the chamber for placement of sampling devices, and a top further redesigned for ease in opening and closing.

This report includes a description of the chamber and aerosol generators with operating instructions, detailed data on testing of the chamber, and a discussion of test results.

The chamber to be delivered to the Army with its aerosol generation systems should meet all the needs of the industrial hygiene unit for testing field equipment and for training personnel in the use of aerosol sampling equipment.

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INTRODUCTION

Aerosol chambers have had a wide use in the field of industrial hygiene, both for research, and in the practice of field industrial hygiene. Research uses include the toxicology of airborne particulate materials occurring in industry, where aerosol chambers are necessary for the exposure of experimental animals to clouds of aerosol alone or in combination with gases or vapors. Also, chambers are used to contain aerosol clouds for determination of such chemical and physical properties as reaction rates, coagulation rates, changes in surface area or surface properties, and the effect of electric charge on the properties of clouds.

Aerosol chambers are of even more use to the practicing, field industrial hygienist, for they allow the development and testing of field methods without the difficulties, complications, delays and expense involved in initial testing of these methods in industrial installations. Collection efficiencies of sampling devices can be determined by the use of the devices in an aerosol cloud while actual concentration and size distribution are determined by methods of known accuracy. Air samples having known mass and composition can be prepared to test analytical laboratory procedures. Commercial air samplers can be quickly tested before field use to assure satisfactory operation. Comparisons of commercial or particulate sampling devices developed in-house can be carried out to compare results with one another and with "standard" devices. The operation and use of particulate sampling devices can be demonstrated to personnel being trained in evaluation of potential airborne particulate hazards in industry. In fact, when such a chamber is available it is difficult to visualize how operations had been carried out in its absence.

To carry out the potential uses of an aerosol chamber it is necessary to have not only the chamber, but methods of generating a range of concentration of a variety of liquid and solid aerosols. Although not absolutely essential, it is desirable to have some method of monitoring the aerosol in the chamber (such a monitoring device was not included in this contract, but recommendations for a suitable device are included in the report). It is necessary to have means of controlling and measuring the dilution airflow through the chamber. It is necessary to know the distribution of aerosol concentration throughout the chamber so that the variance of concentration to be expected at different sampling ports can be predicted. The system must be designed so that aerosols of moderate toxicity can be introduced into the chamber and the airflow discharged without creating a hazard to the operator or to others. However, extremely toxic or hazardous aerosols such as radioactive materials in greater than tracer amounts or pathogenic microorganism require elaborate precautions and redundant safety provisions beyond the scope of an aerosol chamber for industrial hygiene use. The chamber in this contract is designed to handle materials of a toxicity up to those ordinarily found in industry such as lead, quartz, asbestos and cadmium. It is also necessary

to have a written description of the chamber and its appurtenances so that the use of the chamber is not dependent upon the availability of only one or a few individuals.

In the context of the above requirements, under this contract we undertook to design, and construct an aerosol chamber based upon the experience in the use of aerosol chambers in human and animal exposure experiments conducted over the past 40 years in the Kettering Laboratory and the experience of others. Aerosol generation systems for use with the chamber were to be selected, modified or developed as necessary. The aerosol generation systems were to be operated and the variance in concentration throughout the chamber determined by collection of simultaneous samples at the various sampling ports. Based upon the results of testing, a new chamber was to be designed and constructed. The better of the two chambers was to be delivered to the Army Environmental Hygiene Agency with the generation systems, including a description and operating instructions for the chamber and its appurtenances.

This final report includes the description and operating instructions for the chamber and three generating systems. It also includes the results of testing of the chamber using each of the three generating systems. All testing was carried out using the first chamber. The second generation chamber incorporates a side access door, a sampling equipment shelf inside the chamber, and an improved top. No changes were made which would change the performance; all changes were to increase flexibility and convenience in the use of the chamber.

SYSTEM DESCRIPTION

General Components and Flow.

The general aerosol system consists of two separate assemblies: the chamber, pump and filter cart (Figure 1), and the generator cart (Figure 2). The general flow diagram of the aerosol system is shown diagrammatically in Figure 3, to which the following paragraphs refer. The assembly drawings for the aerosol chamber, mixing chamber and the chamber top are shown in Appendix I.

The aerosol chamber (G) is a 28" diameter by 42" high cylinder with a conical transition piece attached to the bottom of the cylinder. At the end of this 8" conical transition piece is the mixing assembly (F). Here the aerosol stream is fed into one side of the small cylinder and clean air is fed from the other side. These two inlets are placed longitudinally to the outer edge of the mixing chamber allowing for optimum air mixing in a small space.

From the mixing area, the air flows up and through the chamber past sampling ports on the chamber side and out through an exhaust port located centrally on the top of the chamber. A hinged top

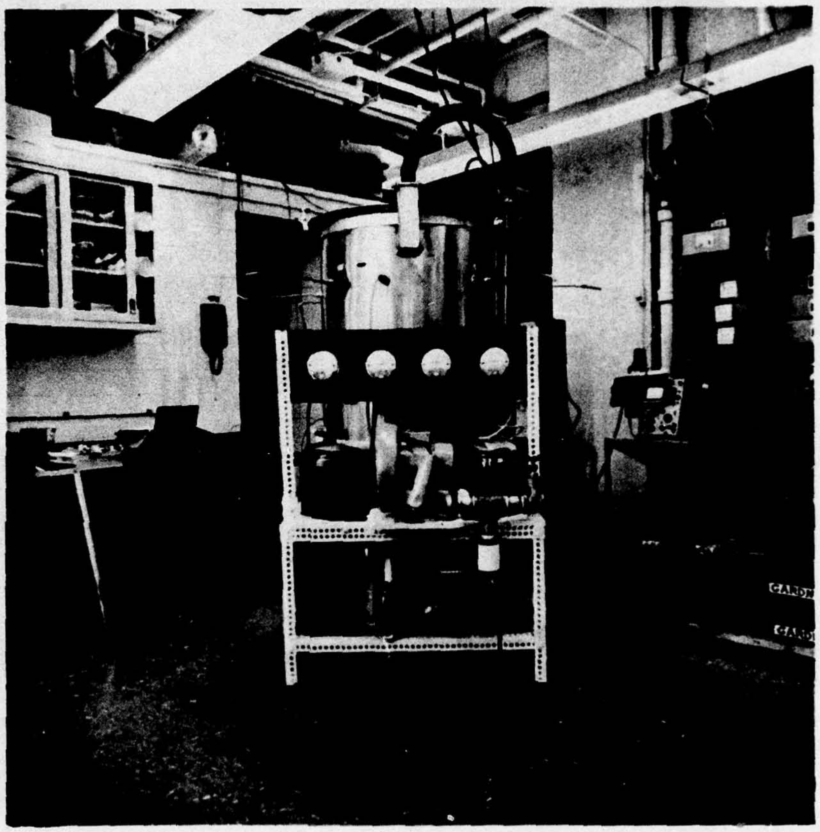


Figure 1. The chamber, pump and filter cart

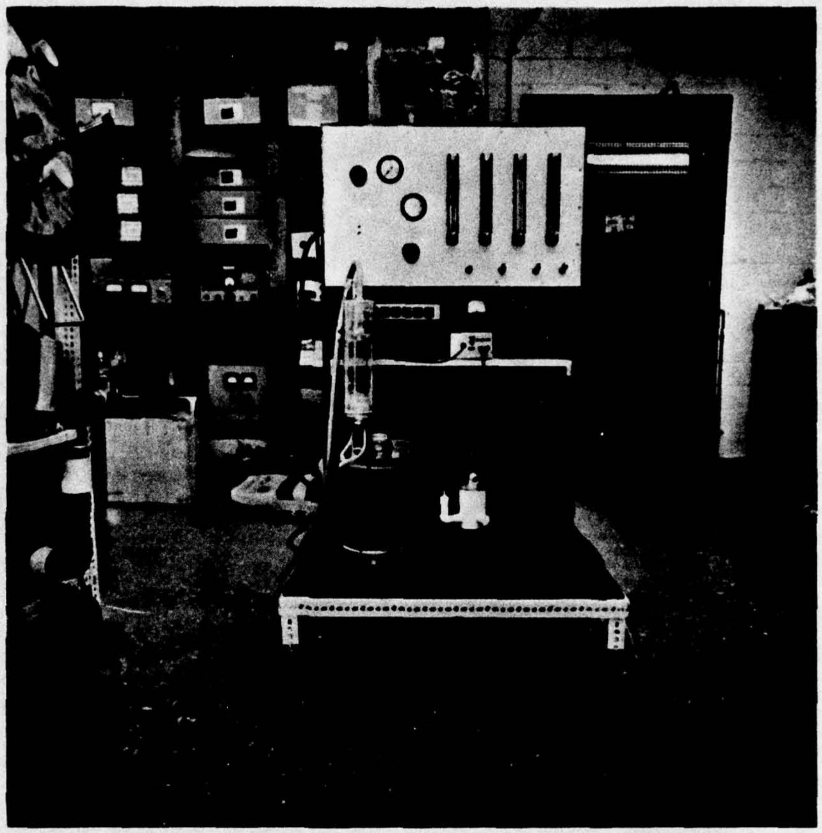


Figure 2. The Generator Cart
(shown on left is the fluidizing generator with dilution cylinder attached; at right is the DeVilbiss Ultrasonic Nebulizer)

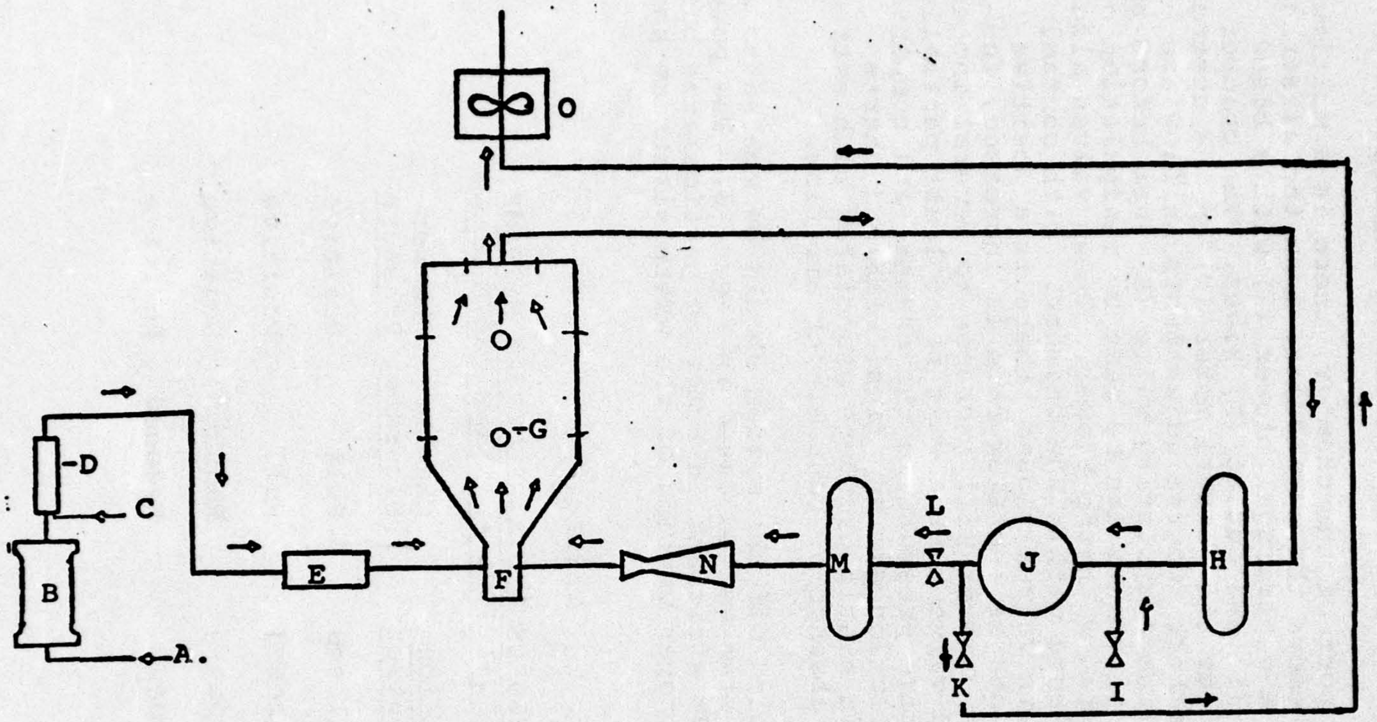


Figure 3. Flow Diagram of System. A) Generator Supply Air, B) Aerosol Generator, C) Dilution Cylinder Air Supply, D) Dilution Cylinder, E) Radioactive Source, F) Mixing Area, G) Aerosol Chamber, H) Post Filter, I) Inlet Bleed Valve, J) Pump, K) Outlet Bleed Valve, L) Inline Restricting Valve, M) Pre-Filter*, N) Venturi Meter, O) Exhaust Fan.

*Pre-filter used only on earlier runs.

allows for easy access into the chamber, facilitating the mounting of test equipment on the inner wall of the chamber or the inner side of the top. Note: Access to the chamber is further facilitated by a side access door in the second chamber.

Connected to the exit port of the chamber, there is a multitube filter assembly (H) to remove the particulate from the airstream. Following the filter is a centrifugal blower (J) with a bleed valve on both the inlet (I) and outlet (K) sides. The chamber airflow rate is measured by the Venturi meter (N) on the upstream or inlet side of the chamber. Course adjustments in flow are readily made with an inline restricting valve (L) just before the prefilter (M). Finer adjustments can be made by manipulation of the bleed valves associated with the blower. These valves also regulate the static pressure within the chamber. With contaminant air flow off and both valves closed, there is a positive pressure in the chamber and as the flow rate is increased, the possible pressure in the chamber will increase to several inches of water. The outlet bleed valve must always be at least partially open to maintain a negative pressure in the chamber and compensate for the generator and dilution air supplies. Table I charts conditions in flow and in static pressure associated with extreme valve positions in the absence of contaminant air flow.

In all cases the air bled off the system should be vented to a hood or other exhaust system as indicated in Figure 3. The post filter is better than 99% efficient in removing particulates but as a safety precaution proper venting of the waste airstream should be required.

TABLE I

CHAMBER PRESSURES AND AIRFLOWS AT EXTREME BLEED VALVE POSITIONS - INLINE VALVE OPEN

	Valve Position		Chamber	Chamber
	Inlet	Outlet	Flowrate	Pressure
1.	Closed	Closed	Full	Positive
2.	Open	Closed	Full	Positive
3.	Closed	Open	Reduced	Negative
4.	Open	Open	Reduced	Positive

Sampling Ports.

The chamber and its top are designed so that symmetrically located samples may be collected simultaneously and be compared to each other for mass concentration.

As shown in Figure 4 on page 15, if a line is established as a reference for all sampling ports in the top and the main body of the chamber, the following ports are available for sampling:

a) On the chamber top at a radius of 10":

1. starting 30° from the 0° line, counterclockwise and 90° apart, four holes accommodating 1/2" stainless steel full couplings which protrude on both sides of the top. Moving clockwise from 0° these ports are identified as T1, T2, T3, and T4.

2. starting 75° counterclockwise from the 0° line and 90° apart, 4 each 49/64" diameter holes, identified as TD, TA, TB, and TC moving clockwise from 0°.

b) In the sides of the chamber body:

1. Four holes for 1 1/4" stainless steel half-couplings located 81 cm up from the bottom 90° apart, starting at the 0° line. These ports are numbered 2, 4, 6, and 8 moving clockwise from 0°.

2. Four holes accommodating 1/2" stainless steel half-couplings also 81 cm up from the bottom 90° apart, starting at 30° counterclockwise from the 0° line, numbered 1, 3, 5, and 7 moving clockwise from 0°.

3. Four holes for 1" stainless steel half-couplings 25 cm up from the bottom 90° apart, starting at 45° counterclockwise from the 0° line, identified as L1, L2, L3, and L4 moving clockwise from 0°.

4. Two holes for 1" stainless steel half-couplings 45 cm up from the bottom 180° apart, starting 45° counterclockwise from the 0° line, identified as M1 and M2 moving clockwise from 0°.

Radioactive Source.

A Strontuim-90 radioactive source (E) has been placed in line between the dilution cylinder of the dust generating system (D) and the mixing head (F) on the bottom of the large chamber. This source with an activity of 100 mCi and a maximum β energy of 2.27 MeV is in the form of a ceramic pellet sealed in a welded stainless steel capsule, with a window thickness of 0.05 mm. The capsule has been glued with epoxy to a 3/4" national pipe thread plug into a threaded hole centrally located in a 4" extra heavy (wall thickness 0.337") steel pipe of 14" length. The inside wall

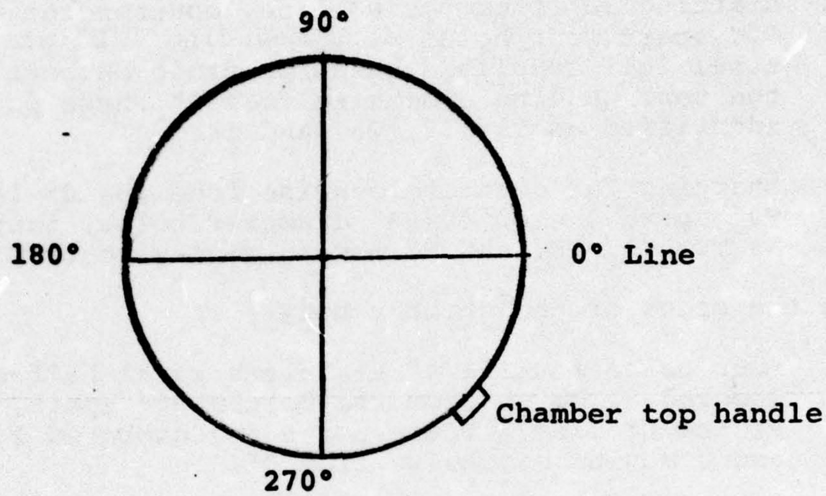


Figure 4. Reference line for port identification

has been lined with 1/4" plexiglass to reduce the generation of bremsstrahlung radiation. The source is used to remove the static charges produced in the generated aerosol and to remove any charge effect on sampler performance.

Aerosol Generators.

Three particulate cloud generators are supplied with the aerosol system: The DeVilbiss Ultrasonic Nebulizer; the Wright Dust Feed; and the Fluidizing Generator. The first two generators are well described in the literature provided in Appendix II of this report and are only briefly described below. The Fluidizing Generator is a relatively new method of dust dispersal; therefore, its operations are discussed in more detail.

DeVilbiss Ultrasonic Nebulizer: The ultrasonic nebulizer is a device that is able to produce high output concentrations of water or other liquid solutions. It has definite advantages over conventional air blast nebulizers; notably that it produces higher concentrations of aerosol, and that it has no small orifices which clog easily. The unit consists of a chamber fitted with a flexible plastic diaphragm at its base. The chamber has air inlet and outlet ports in the side and top. The whole chamber assembly rests in a water bath containing an ultrasonic generator (operating at 1.35 MHz). The water couples the 1.35 MHz transducer to the solution inside the aerosol chamber through the flexible plastic diaphragm. The resulting ultrasonic energy produces dispersion of the aerosol solution. A cone or fountain effect is visible through the chamber top when the ultrasonic generator is operating, and the resulting droplets are swept away by the airstream admitted and exhausted through access ports (1).

In our use of the nebulizer, the clean air was introduced through the side port at a rate of 50 liters/minute and directed the aerosol stream out through the access port on the top of the device. Immediately after exiting the nebulizer, the aerosol stream was further diluted by approximately 56 liters/minute of dry air in the dilution cylinder before passing into the bottom of the test chamber. The dilution assembly is described in another section of this report.

In our application of this generator, isopropyl alcohol was used to dilute the uranine (disodium fluorescein) to 14% by weight. Further dilutions were accomplished with distilled water. The isopropyl alcohol-water mixture was used to assure rapid evaporation of the liquid portion of the droplet. In our normal procedure, uranine solutions of 1.75% weight percent were nebulized in the generator. The use of uranine as an aerosol allows the use of spectrophotometric analysis techniques rather than weighing for the resulting aerosol. Filter samples can be obtained, diluted with a known volume of distilled water and the uranine concentration determined using a conventional spectrophotometer, 1 cm cell length, set at 490 nm wavelength. The optical density determi-

nation on the elution from the sample filter is compared to a calibration curve (see Appendix III) and the concentration of uranine in micrograms per milliliter of solution is determined. The usable range of concentrations covered by the calibration curve used was from 0.1 to 8 μg/ml.

Wright Dust Feed: The Wright Dust Feed is perhaps the most common dust redispersion device used today. This system, as depicted in Figure 5, exhibits the classic advantages and disadvantages of redispersion methods. Dispersion of nearly any material powderized to less than 20 μm in diameter can be accomplished by filling the dust container (A) with the powder and packing it with a rammer or press. The filled container (A), screwed snugly into the cap (B) is screwed onto the top of the threaded spindle (F). A motor (S) runs at a constant speed of 1 revolution per minute. The system generates solid aerosol particles by the scraping action of the cutting edge (O) against the packed sample of the particles, permitting the particles to be swept from the unit by dry air (2). Again, as in the nebulizer, the aerosol stream was further diluted in the dilution cylinder with 56 liters/minute.

The rate of feed to the airstream is adjusted by two methods. First, the container (A) may be used at full capacity or with an inset aluminum liner which effectively reduces the capacity of the container eight times. Secondly, a number of standard gears may be interchanged at "U", "V", "W", "X" and "D" to yield gear ratios ranging from 15:1 to 1:15 (2). The gear ratio required in any one dynamic system to produce a given concentration must be determined experimentally. The mechanism is meant to run continuously without attention and will automatically disengage when the container (A) is empty. Other safety precautions are built into the mechanism to prevent overloading of the motor. Good practice prescribes several limitations to the system. Hygroscopic dusts should be avoided to limit agglomeration problems. Similarly, fibrous dusts can accumulate on the scraper and clog it. Additional problems of agglomeration and clogging will occur if the compressed air supplied to the device is not of the highest quality. To assure adequate dispersion excess moisture or oil in the compressed air supply must be removed by filtration and drying agents. The air pressure necessary to operate the dust filter depends partially upon the volume of dusty air required in the system. However, pressures less than 3 psi will not completely disperse the dust and should generally be avoided. As recommended in the instruction manual for the device, 10 pounds per square inch gauge (psi) was used in the testing of the system. Careful attention to the dust and air source should help assure few breakdowns and minimum maintenance.

As in most aerosol generation systems, there are certain areas where careful attention to detail is necessary. Since the output of the generator largely determines the aerosol concentration and stability with respect to time, poor technique in pressing the

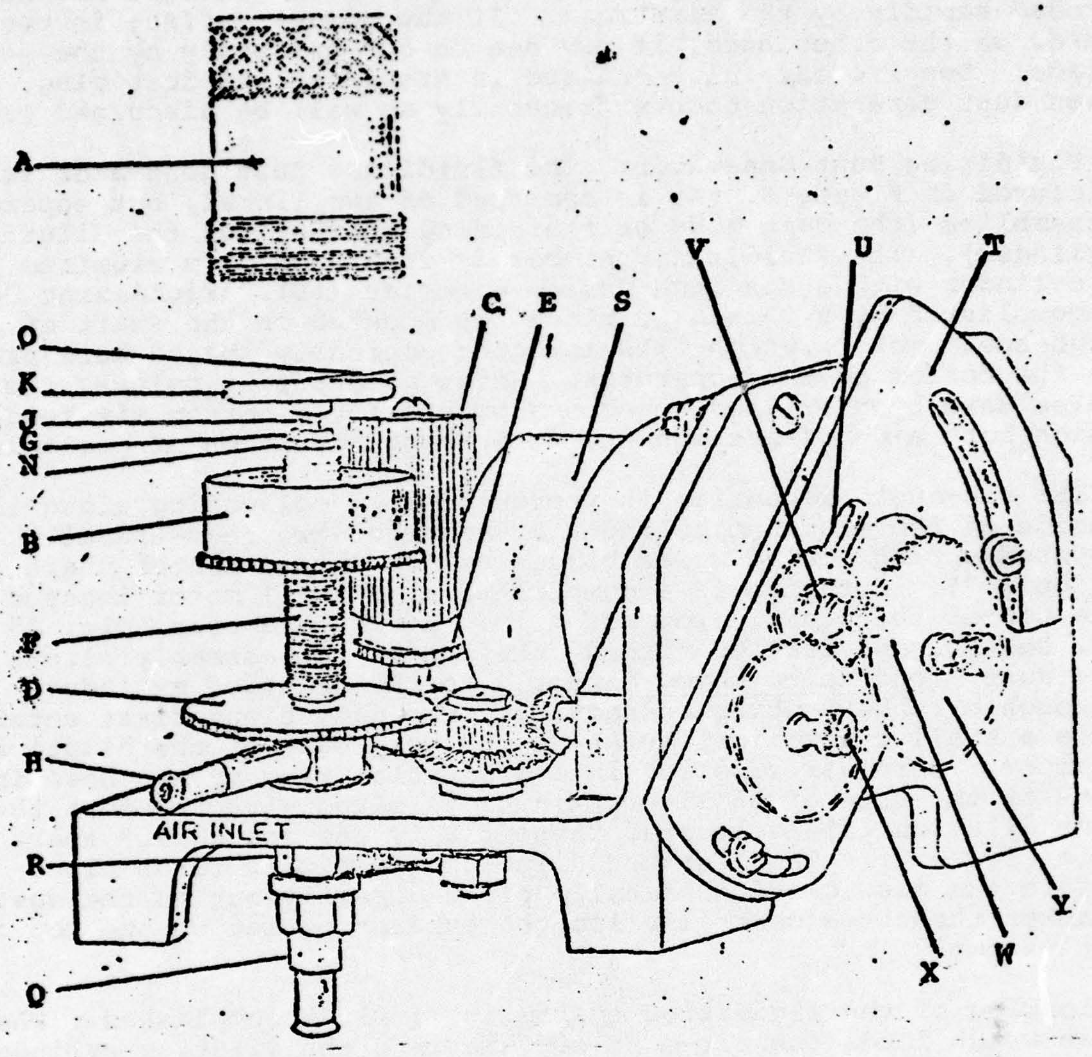


Figure 5. The Wright Dust Feed (2)

A. Dust Container
B. Cap
C. Long Pinion
D. Gear on Threaded Spindle
E. Small Pinion
F. Threaded Spindle
G. Main Spindle
H. Air Inlet Connection
J. Dust Tube
K. Scraper Head
N. Spring Ring

O. Scraper Blade
Q. Outlet nozzle (containing baffle)
R. Main Spindle clamping nut
S. Synchronous Motor
T. Gear Plate
U. "Driven" Gear
V. "Driving" Gear
W. Counter Shaft
X. Cross Shaft with fitted Gear
Y. Motor Spindle Gear

powder into the cup can produce large fluctuations in concentration. Excessively porous or non-uniform powder charges may be eroded rapidly by the airstream. If the powder surface is too hard, on the other hand, it may not be cut uniformly by the scraper blade. Despite careful technique in preparing the dust plug, uneven dust generation occurs frequently as will be discussed later.

Fluidizing Dust Generator: The fluidizing dust generator is pictured in Figure 6. It is composed of two linked, but separable assemblies (the main body or fluidizing chamber and the dilution cylinder). The fluidizing chamber is fashioned from aluminum into a cylinder with a six inch inside diameter (ID). Fluidizing is accomplished by a 3-inch 10 blade fan mounted on the shaft of a high-speed motor, which fits into the conically shaped base plate on the bottom of the apparatus. Here, at opposing points, two holes have been drilled as access points for a bottom air feed, which both aids dispersion and deters agglomeration of particles.

The air-dust suspension is prevented from collecting along the inside of the aluminum cylinder by means of two geometrically opposed spring loaded wiper blades attached to a center shaft (Figure 7). Rotation is accomplished by a small motor located at the top of the plastic top assembly. A 5/8" diameter hole, 2" off center, and drilled through the top of the assembly allows the dust cloud to be moved directly to the dilution cylinder through a rubber tubing connection. The dust cloud first enters into a small cylindrical inset at the very base of the dilution chamber. Here air supplied into a circular ring by two hose inlets at the rate of 56 liters/minute is mixed with the dust through four dilution inlets located tangentially and spaced 90° apart (see Figure 8). Thus further dilution and mixing takes place before the dust cloud is finally piped directly out to the dust chamber through a centrally located exhaust outlet on the top of the assembly.

Loading of the fluidizing system is simply accomplished. The hose which feeds the air-dust mixture into the dilution cylinder is removed, and dust is fed through a funnel whose stem piece fits into the resulting hole on the plastic top assembly. When loading quantities of dust in excess of 50 gms., dust tends to pile up on the floor of the base plate partially encompassing the wiper blades. It is important to keep the blades running when loading to prevent the motor from stalling during start-up procedure.

Alternatively, dust may be loaded en masse simply by spilling the total load into the fluidizing chamber with the top removed. Again, in order to prevent the wiper blade motor from stalling, it is necessary to clear any dust load from the outer edges of the base plate, before securing the top.

Dust loadings from 50-80 grams per run successfully used in the testing of this generator.

2.7 liters/minute of bottom feed air and 22 DC volts supplied to

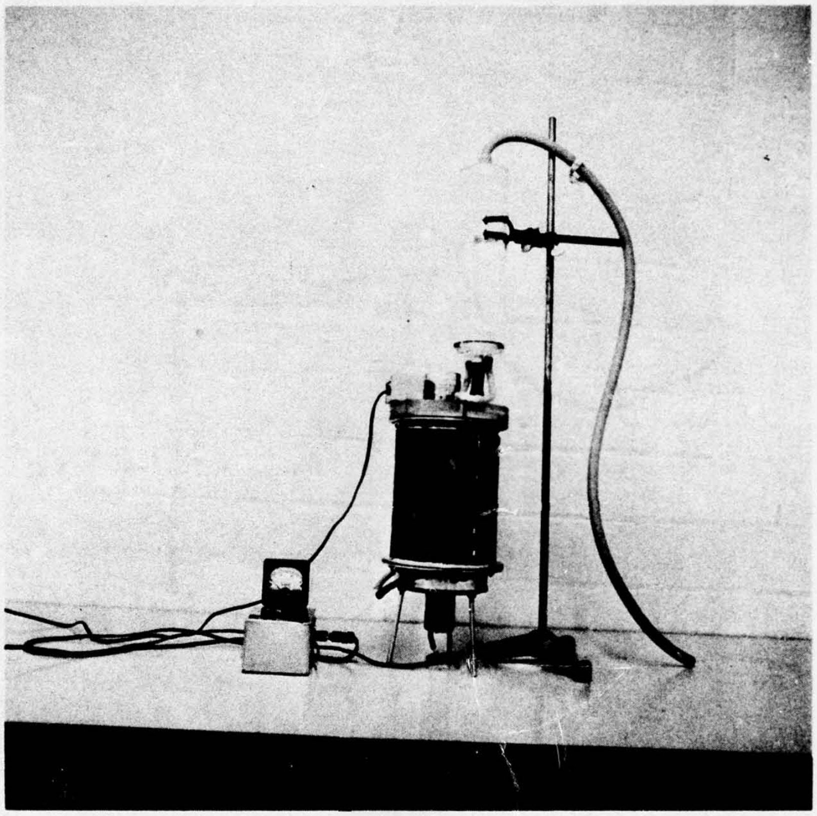


Figure 6. The Fluidizing Dust Generator with Dilution Cylinder Attached (power source for fluidizing blade pictured at left)

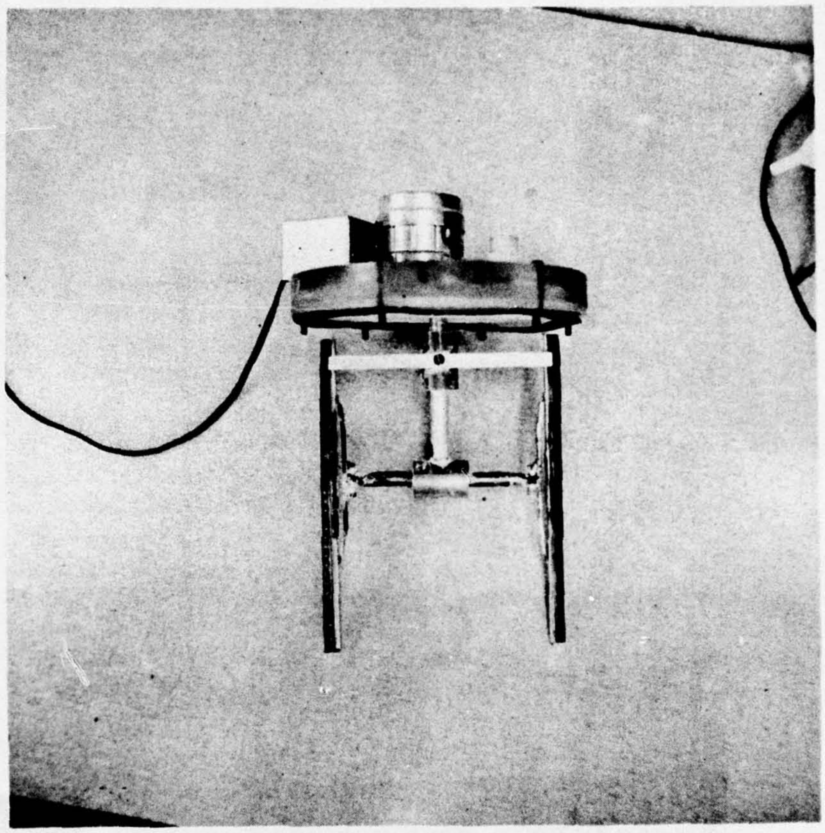


Figure 7. Spring Loaded Wiper Blades of Fluidizing Generator

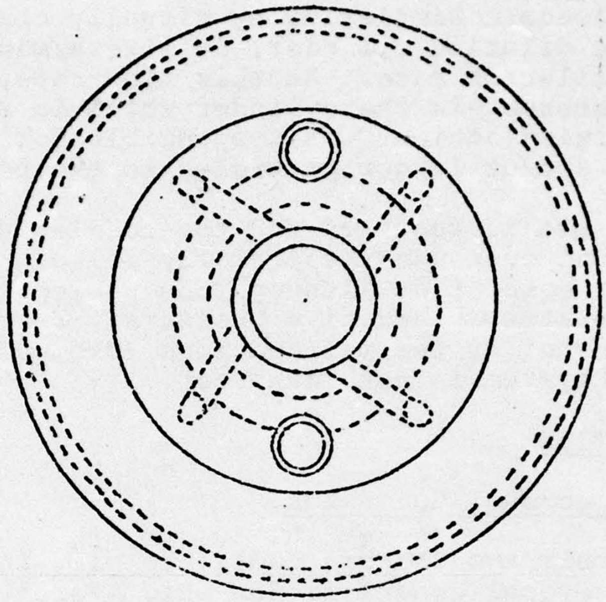


Figure 8. Top View of Dilution Cylinder (note the four tangential air inlets)

the fan motor (equivalent to 4700 rpm) are the normal operating values for the apparatus. By visual inspection through the plastic top assembly of the fluidizing chamber, these parameters were chosen as they seemed to give optimal mixing of the dust load without excessive impaction on the roof of the chamber. Voltages less than 8 volts caused stalling of the fan blade with normal dust loads. Similarly, by visually observing the mixing action in the dilution cylinder, 56 liters/minute was chosen as the optimal dilution rate. At this flow rate, a cyclonic mixing action was observed in the cylinder which in addition to producing an optimum mixing action, was responsible for knocking out agglomerates and/or larger particles to the bottom of the cylinder.

Respirator use is required for the loading procedure to prevent exposure to the dust used, especially if spillage should occur. It is further noted that although the whole generating system routinely operates at negative pressures, respirators should be nearby in case of system malfunctions (clogged or crimped hoses, etc.) as the system is not leakproof.

SYSTEM OPERATION

Selection of Aerosol Generator.

Basically only two factors come into play in choosing the appropriate aerosol generator for this system. These are first, and most importantly, the type of aerosol needed to be generated; and secondly, the length of time one wishes to generate the aerosol cloud.

The nebulizer is an obvious choice for those substances such as uranine or simple table salt (NaCl) which are easily dissolved in a liquid solution. Relatively high and steady concentration outputs are possible. The DeVilbiss Ultrasonic Nebulizer has the additional advantage of being able to produce aerosols for very lengthy periods as attachments are available which allow for a continuous flow of solution into the aerosol chamber from a reservoir.

The choice of generators for dusts is less easily made. However, features of both the Wright Dust Feed and Fluidizing Generator are advantageous in specific situations. The Wright Dust Feed can produce an aerosol stream for lengthy time periods while higher concentrations of dust can be produced with the Fluidizing Generator. With the dust cylinder about 2/3 packed and operating at a gear ratio of 36:36:36:54, the Wright Dust Feed can be expected to operate up to 20 hours. The Fluidizing Generator cannot operate without a significant loss in output for more than 60 minutes. This unit is expecially advantageous for those dusts which might resist packing (e.g., Attacote, produced by Attapulgus Clay Company) and are, therefore, nearly impossible to use with the Wright Dust Feed.

Operation.

DeVilbiss Ultrasonic Nebulizer: Detailed instructions for servicing and operation of this unit are available in the Appendix. However, the following steps summarize the procedures for operation and can be easily followed after a basic familiarization with the unit.

1. Fill the base of the unit (the couplant compartment) with water to approximately 3/4" from the bottom. During operation of the unit, a red light will light if additional couplant needs to be added.

2. The solution is added to the nebulizing chamber through the top, which is easily both removed and secured. For a single run, no more than 180 ml of solution can be added so as not to exceed a level just below the air supply inlet.

3. Place the nebulizer chamber in its proper position in the couplant compartment.

4. Plug one of the two elbows protruding from the nebulizing chamber. The other is attached by rubber or plastic tubing to an appropriate air supply.

5. Attach the pipe extension from the nebulizer top to the bottom of the dilution cylinder.

6. Select the desired power setting. Power settings determine the volume of aerosol output and are experimentally determined. When operating at lower power settings it is necessary to momentarily increase the setting to initially create the aerosol geyser. The power setting may then be reduced to the desired operating setting (1). The maximum power setting of 10 was used in our experimental procedures.

7. Recheck all attachments. The unit is then ready to turn on.

Wright Dust Feed: Detailed instructions for servicing and operating this unit are available in the Appendix. With familiarization of the unit, these basic steps are easily followed (refer to Figure 5, page 18):

1. Select the gear ratio desired and attach appropriate gears at X, Y, and V.

2. Fill the container (A) with dust and pack to desired pressure. Screw the dust cup (B) to the top of the threaded spindle (F) as far as it will go and then screw the container (A) into the cup. Screw the container until contact is made with the scraper head (K) indicated by a slight resistance. Push the pinion (C) to engage the pinion (B) with the wheel (D).

3. Attach the air inlet hose to the air supply (10 psi gage

recommended). Attach the air outlet to a hose connecting it with the dilution cylinder.

4. The unit is ready to operate by:

   a. turning on the air supply and

   b. turning on the mechanism

Fluidizing Dust Generator:

1. Load the desired dust load into the fluidizing chamber en masse with the top removed or with a funnel through the hole left by removing the hose which leads to the dilution cylinder. Remember to operate the wipers while loading.

2. Secure top.

3. Hook up the hose from the top of the fluidizing chamber to the dilution cylinder.

4. Attach the bottom feed air hose to the fitting provided and to the appropriate air supply.

5. Set the voltage operating the fluidizing blade. (22 volts recommended).

6. Check all connections, make sure the top is secure and the wipers are operating.

7. The unit is now ready for operation. Generally the air supply is turned on before starting the fluidizing blade.

Chamber Start-Up and Operation: The chamber requires only a few simple steps to assure safe operation (see Figure 3, page 12).

1. All sampling equipment should be placed and secured in the proper position.

2. Check that all ports are sealed to assure a leakproof operation.

3. Close the chamber top and secure by closing the clamps provided.

4. Attach the hose from the chamber exhaust port to the piping leading to the after filter.

5. Check to see that the hose from the dilution cylinder (D) is connected to the piping leading to the radioactive source (E).

6. The chamber is ready for startup. To start the chamber, the pump is switched on and the associated valves are adjusted to give the desired flow ratio and pressure. Further adjustments may be needed when the sampling equipment is turned on.

7. Normally, the aerosol generator (B) startup follows chamber startup. When assured the generator is working properly, sampling equipment is turned on and the time noted.

8. Operation involves only periodic checking of all systems to assure they are operating.

When the sampling units and pumps are turned off, flow through the chamber should continue for approximately 10 minutes to assure adequate flushing of the system.

PROCEDURES AND EQUIPMENT FOR SYSTEM TESTING

System Parameters.

The prototype test unit which was used in initial runs (M1 through M5) utilized a water manometer connected to an orifice meter to monitor air flow through the chamber. The air flow through the chamber was approximately 0.02 meters^3 per second as indicated on the manometer by 4.0" H_2O. This clean air flow rate could only be adjusted with an inlet bleed valve on the pump. Control of static pressure in the system was, therefore, impossible. However, a static pressure in the aerosol chamber of -4.0" H_2O was associated with the 40 cubic feet per minute rate. The final system configuration, in which a Venturi meter replaced the orifice meter, and in which two bleed valves and an inline restricting valve were added to the piping arrangement, was utilized for all other runs. As previously mentioned, this allowed for variable flow rates while also controlling static pressure. Rates varying between 24.5 and 51.0 cubic feet per minute were routinely used in the series runs while static pressure was held at -1.0" H_2O. For each generating unit, runs were made at 0.012, 0.016, 0.020 and 0.024 cubic meters per second.

Sampling Equipment.

Total dust sampling was performed using Gelman 47 mm filter holders with Whatman 47 mm glass fiber filters. In the routine configuration, one of these sampling units was mounted at each of the eight ports located 81 cm up from the chamber bottom. These filters, mounted using 1/2" aluminum tubing and the appropriate Swagelok fitting, protruded approximately 1-1/2" from the chamber wall. Sampling was also performed with the filters arranged spirally within the chamber. Starting with a filter 2" away from the wall and moving clockwise, each successive filter was moved 2" closer to the center of the chamber so that the seventh filter was centrally located. The eighth filter was placed as near the wall as possible. This resulted in an arrangement as pictured in Figure 9. This arrangement provided an easy method for determining whether dust concentration varied with the distance from the side wall.

The eight filter samples were connected by rubber tubing to an

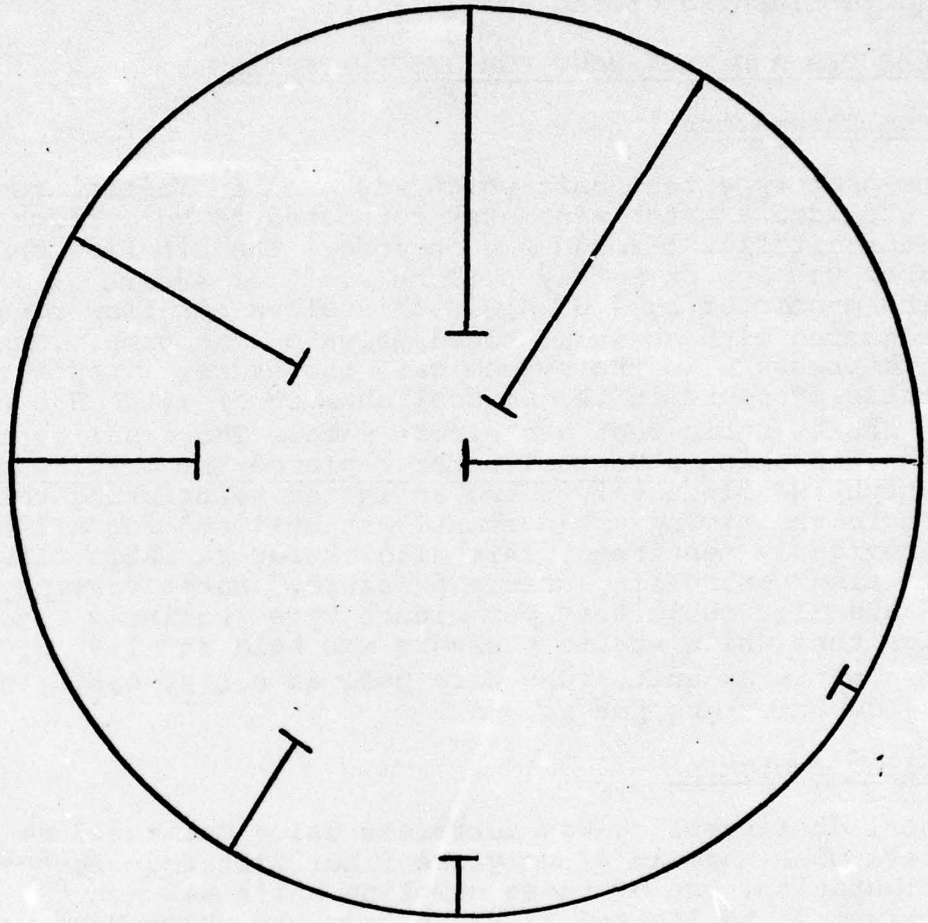


Figure 9. Diagram of Spiral Filter Arrangement within the Test Chamber

eight branched, multi-sampling unit; each branch contained a critical orifice constructed from a hypodermic needle (Figure 10). This particular system had two distinct advantages. First, it assured the collection of simultaneous samples as only one pump was needed to draw the air through the orifice for all eight samples. Secondly, identically constructed critical orifices allowed dust collection at approximately equal flow rates (ranging from 4.56 to 4.78 liters/minute. Thus, any sampling errors due to differences in rates and/or techniques were minimized. Sampling was also performed with filter holders screwed directly onto the multiport unit, and this assembly mounted directly in the chamber through port 6.

Sampling from the chamber top was done in a similar manner. Filter holders were placed from 2"-2.75" from the top to approximate the sampling inlet location of the cyclones which were tested in several runs. Again, critical orifices constructed from hypodermic needles were utilized, but, flows were larger and covered a wider range - from 9.40 liters/minute to 12.24 liters/minute. Calibration of all of these orifices was accomplished using a wet test meter.

Aerodynamic sizing of the dust cloud within the chamber was accomplished using a seven-stage Andersen sampler (Figure 11). This instrument operates by drawing an airstream through a series of identical jets against a filter plate set at right angles to the jets on which a Whatman 41, 7.9 cm ashless filter paper is placed. In the next stage, air moves through smaller jets at higher velocities, continuing this process through seven stages. Larger particles are impacted on the first stage from the largest jet, and successively smaller particles are impacted on succeeding stages. A backup filter collects particles too small to be impacted on the last stage. An Effective Cutoff Diameter (ECD) exists for each stage. This is the aerodynamic diameter at which 50% of the particles are impacted on a given stage (3). Knowing the mass deposited on each stage and the corresponding ECD, the mass median aerodynamic diameter (MMAD) and the standard geometric deviation are easily calculated. The Andersen sampler was operated at 28.3 liters/minute (1.0 cfm). ECD's for this flow rate are as follows (3):

Stage No.	ECD (micrometers)
1	-
2	5.35
3	2.95
4	1.53
5	0.95
6	0.54
7	0.24

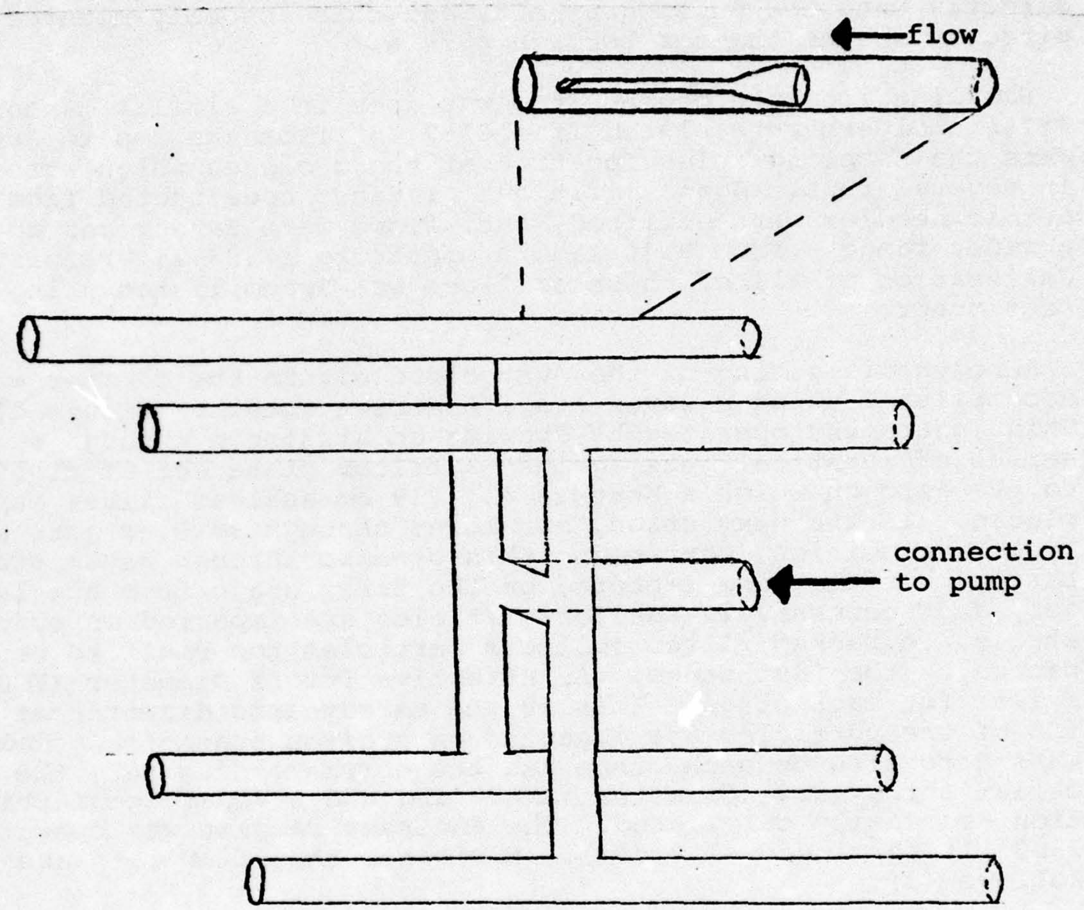


Figure 10. Schematic of Multiport Sampling Unit

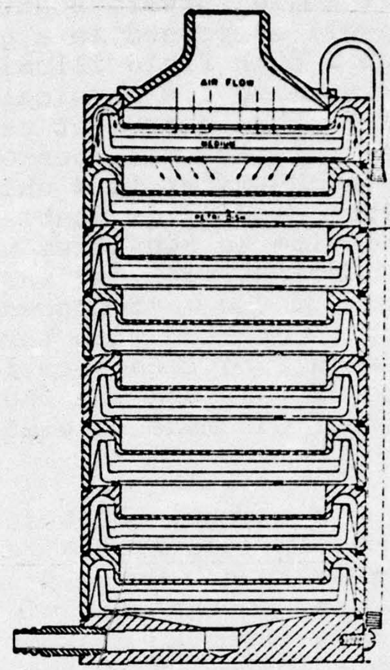


Figure 11. Schematic of the Anderson Sampler

A Sinclair - Phoenix aerosol, dust, and smoke photometer was used to characterize short-term concentration fluctuations and general system performance. This unit, which instantaneously determines concentration, was connected to a Cole-Parmer Mark IV strip chart recorder giving a continuous record of the variation in concentration during any given period. The meter reading is a function of the small angle forward scattering of light by dust particles (or any aerosol) dispersed in a gaseous medium and continuously drawn through a dark field illumination chamber. For any given dust cloud, assuming its physical characteristics remain relatively constant, the instrument reading is proportional to the logarithm of the relative mass concentration (4). The full-scale deflection on the meter is 5 units and 10 units on the recorder. Thus any meter reading is doubled on the strip chart record. Although the device is sensitive within an extremely wide range of aerosol concentration, it was used in this test only as a relative guide to the mass concentration in the chamber. The instrument calibration drifted with time and/or use up to 0.5 units meter scale requiring recalibration of the unit with each test run. Because of this and the fact that meter readings are logarithmic, no effort was made to equate chart reading with exact concentration.

Two different types of cyclones, the Unico 240 dual inlet model and the Aerotec "3/4" model, were available to collect samples in several of the latter test runs. Up to four Unico 240's were attached to the chamber top so that the middle of the sampling inlet extended 2-3/4" down from the chamber top in the 3/4" ports (TA,TB,TC, and TD) located on a 10" radius from its center. Two Aerotec "3/4" cyclones were also fitted into the chamber top, screwing directly into the inner half of the full coupling at the appropriate ports (T1 and T3). Filter holders containing 47 mm Whatman glass fiber filters were mounted to the upper half of the coupling. Alternatively, these cyclones were threaded directly into the side of the chamber from the outside at ports 3 and 7 with the filter holder mounted directly atop the cyclone. This position resulted in wall sampling. Flow rates of 75 liters/minute for the Unico 240's and 25 liters/minute for the Aerotec "3/4"s were measured with conventional rotameters (Dwyer) incorporating needle valves for flow control.

Weighing Filters.

Whatman 47 mm glass fiber filters were weighed on a Mettler M5 SA six-place balance. The Whatman 41 mm filters from the Anderson sampler and the Whatman 10.16 cm glass fiber filters from the Unico 240's were weighed with a Mettler H10 four-place balance. Filter weights were determined only after setting in the appropriate balance room for at least two hours to minimize errors due to moisture gain or loss. Blank filters were used and treated likewise; any differences in pre- and post-weighings were subtracted out from the samples if significant.

RESULTS

Data Classification.

Each run in Appendix IV and data tables is referred to by a capital letter (M, N, W, or F) and a number. A run designated by the letter M means that these data were compiled either when the chamber was not in its final test configuration or before the standardized settings with each generator were chosen. Nine such data runs were completed and they are numbered sequentially 1 through 9 as they were performed. The letters N, W, and F are used to classify data collected with the chamber system in its final configuration and with the standardized generator settings (power, air-flow, dust loading, etc.). Air flow through the chamber was the only variable parameter. Each of these capital letters refer to a particular generation method as follows: N-the DeVilbiss Ultrasonic Nebulizer, W-the Wright Dust Feed, and F-the Fluidizing Generator. Numbers after each particular letter refer only to the order of the data run. For example, F3, designates the 3rd data run completed with the Fluidizing Generator with standardized settings. Standardized settings for each generator are given in Table II.

TABLE II

STANDARDIZED RUN PARAMETERS FOR EACH OF

THE THREE AEROSOL GENERATORS

I. DeVilbiss Ultrasonic Nebulizer

56 liters/min. to dilution cylinder
50 liters/min. to Nebulizer
Power setting 10
120 ml of 1.75% uranine
30 minute sampling time

II. Wright Dust Feed

56 liters/min. to dilution cylinder
10 psi to cutting edge
gear ratio 36:36:36:54
Pennsylvania bituminous coal dust packed to a pressure of 1 ton
30 minute sampling time

III. Fluidizing Dust Generator

56 liters/min. to dilution
2.7 liters/min. bottom feed air
22 DC volts supplied to fan motor (4700 rpm)
50 grams of Attacote
30 minute sampling time

Appendix IV presents the dust concentrations in mg/m^3 found at each port sampled for mass concentration. Under the capital letter and number which classified each data run, several other pieces of information are made available. In runs M1 through M9 the dust generation method for the particular data run is listed. Any parameters different from those listed in Table III are also listed here. In addition, the air flow in m^3/s through the chamber is given. Unless otherwise indicated, mass concentration samples gathered from ports 1 through 8 were collected with the filters mounted 1 1/4" from the chamber wall. To get a clear picture as to the uniformity of the aerosol concentration, the mean value and the standard deviation for samples collected at equivalent geometric ports is listed. For samples collected from ports 1 through 8 the mean is listed as $\bar{x}$; for those samples collected from ports T1 through T4 the mean is designated as $\bar{x}_T$.

Unico 240 and Aerotec "3/4" respirable cyclones were used to separate "non-respirable" dust from samples in runs W5, F3, F4, and F5. Again dust concentration is given in mg/m^3. This value, considered the respirable concentration of the dust sample; when divided by the mean of the mass concentration samples collected at geometrically similar ports yields the percentage of the dust generated which is "respirable". When one considers the dust size as determined by the Andersen impactor, this percentage becomes valuable in determining cyclone performance.

In the course of collecting data, several samples were lost due to dropping of the filter, crimping of sampling hoses, etc. In these cases a dashed line is indicated in the appropriate slot. In runs W4 and W5, cyclones were used in ports normally used for collecting total mass concentration samples. Again a dashed line has been placed in the appropriate slot to indicate a total mass concentration sample was not collected at this port.

Aerosol Distribution and Mass Concentration.

Min-U-Sil 15 was the dust generated in runs M1 through M5. Mean values of total mass concentration ($\bar{x}$) ranged from a low of 13.65 mg/m^3 for run M5 to a high of 52.78 mg/m^3 from run M3. Standard deviations of mass concentration about the mean grew larger with increasing concentration. However, these values were small and when considered as a percentage of the mean reach a maximum of only 7% for run M3. When treated similarly, standard deviations for the remaining runs were a smaller percentage of the mean.

In runs M7, M8, and M9, and N1 through N5, a uranine aerosol was generated with the DeVilbiss Ultrasonic Nebulizer. Samples from run M7, analyzed spectrophotometrically, yielded mean values at side and top ports ($\bar{x}$ and $\bar{x}_T$) of 9.35 and 12.5 mg/m^3, respectively, i.e., the mean for the top ports was 1.3 times that for the side ports. The coefficients of variation (100 x standard deviation/mean) were 18% for the side and 9% for top ports. Samples from runs M8 and M9 were analyzed spectrophotometrically

Table III

Data Run	Aerosol	Aerosol Generator	Chamber Flow Rate (CFM)	$\overline{X} \pm \sigma$ (mg/m^3)	$\overline{X}_T \pm \sigma$ (mg/m^3)	MMAD (μM)
M1	Min-U-Sil 15	Wright Dust	40	14.06±0.29		
M2	Min-U-Sil 15	Fluidizing	40	30.82±0.41		2.0
M3	Min-U-Sil 15	Fluidizing	40	52.78±3.85		1.45
M4	Min-U-Sil 15	Fluidizing	40	18.14±0.68		
M5	Min-U-Sil 15	Fluidizing	40	13.66±0.25	12.29±.18	1.48
M6	Attacote	Fluidizing	46	7.13±0.09	6.67±.19	5.7
M7	Uranine (3.5%)	Nebulizer	46	*9.35±1.68	*12.50±1.17	*1.45
				*3.20±0.21	* 3.27±0.21	
M8	Uranine (7%)	Nebulizer	42	3.44±0.04	3.60±0.14	1.50
				*15.95±0.44	*15.52±0.26	
M9	Uranine (1.75%)	Nebulizer	33	17.43±0.45	16.80±0.18	1.24
N1	Uranine	Nebulizer	42	6.57±0.13	6.23±0.10	1.07
**N2	Uranine	Nebulizer	42	6.50±0.09	6.35±0.11	0.93
N3	Uranine	Nebulizer	51	4.90±0.13	4.78±0.12	*1.05
N4	Uranine	Nebulizer	33	8.12±0.14	7.67±0.21	*1.00
N5	Uranine	Nebulizer	24.5	10.07±0.31	9.61±0.20	*1.13
W1	Coal Dust	Wright Dust	24.5	70.04±0.73	67.41±1.30	2.1
W2	Coal Dust	Wright Dust	24.5	9.88±0.14	9.34±0.19	2.6
W3	Coal Dust	Wright Dust	33	5.07±0.05	4.93±0.07	2.9
W4	Coal Dust	Wright Dust	51	3.88±0.12	3.75±0.10	2.65
**W5	Coal Dust	Wright Dust	42	19.58±0.94	18.49±0.31	2.4
**F1	Attacote	Fluidizing	24.5	16.49±1.05	17.39±0.44	
F2	Attacote	Fluidizing	33	12.25±0.26	10.82±0.46	4.6
F3	Attacote	Fluidizing	42	18.21±0.35	16.64	5.5 (lower)
						4.5 (upper)
F4	Attacote	Fluidizing	42	17.32±0.46	16.65±0.83	6.5 (lower)
						4.7 (upper)
F5	Attacote	Fluidizing	51	18.83±0.47	18.25±1.14	4.8

*Spectrophotometrically Determined
**Spiral Filter Arrangement

and by weight. Spectrophotometric determinations yielded results which showed slightly lesser concentrations (approximately 8-10%) than those analyzed by weight. Differences between $\bar{x}$ and $\bar{x}_T$ were small and comparable for both methods. Runs N1 through N5 yielded mean values ($\bar{x}/\bar{x}_T$) ranging from 4.90/4.78 mg/m^3 to 10.07/9.61 mg/m^3. As a group, standard deviations were smallest for this group of runs, never exceeding 3% of the mean value.

Runs W1 through W5 also yielded very favorable results when comparing side and top sampled mean concentrations of coal dust, i.e., $\bar{x}$ to $\bar{x}_T$. Standard deviations were less than 5% of the mean concentration, with the exception of run W5 in which the spiral filter configuration was used.

In runs M6 and F1 through F5, the fluidizing generator was used to produce a dust cloud of Attacote in the sampling chamber. The mean values of total mass concentration at the side ports ($\bar{x}$) ranged from 7.13 mg/m^3 for M6 to 18.83 mg/m^3 in run F5. Concentrations measured from the top ports, $\bar{x}_T$, except for run F1, were found to be slightly less for these runs, ranging from 6.67 mg/m^3 to 18.25 mg/m^3. Again standard deviations at either side or top ports were minimal. Generally, however, slightly higher deviations were found from samples collected at top ports. The largest standard deviations were found on run F1 in which spiral filter settings were used. A summary of these data are presented in Table III.

Cyclone Collection.

The Unico 240 cyclones, suspended from ports TA, TB, BC, and TD in run W5 passed to their back up filters an average of 54% of total coal dust concentration when sampling at 75 liters/minute. Filter collection from individual cyclones when compared to the mean varied approximately 10% as a maximum.

In runs F3, F4 and F5 the Unico 240 cyclones were determined to pass to their filters from 54-58% of total dust concentration. Aerotec "3/4" cyclones passed 39-44% of the total dust concentration for these same data runs operating at 25 liters/minute. For these cyclones the maximum difference in dust mass passed to their filters when sampling from ports T1 and T3 as opposed to sampling from ports 3 and 7 was only 5% (39-44%). This data is presented in Appendix IV.

Particulate Sizing.

The Andersen particle sizing air sampler as pictured in Figure 11 was used in all data runs for sizing the aerosol cloud in the chamber with the exception of runs M1, M4, and F1. These particle sizing results are presented in Appendix IV in which a table of results for each run is prepared indicating the effective cut-off diameter (ECD) for each numbered Andersen stage, the percent of total weight collected by each individual stage, and the cumulative percent weight found by continuously summing the percent weight of

each stage to the previous total proceeding from stage 1 to the back-up filter. Each table is then followed by its corresponding distribution curve prepared on 2 cycle log-probability paper. Run M9 has two tables as this sample was analyzed spectrophotometrically and by weight. These results compare favorably as seen easily by viewing corresponding curves. Runs N1, W1, F3 and F4 each have two tables as two Andersen samples were collected for each of these runs. A log-normal particle size distribution is indicated for Min-U-Sil 15, coal dust, and Attacote as straight lines can be drawn to indicate the size distribution. However, a straight line is not obtained for data runs in which uranine was generated with the ultrasonic nebulizer. Curves characteristically flatten out near the MMAD indicating that distribution was not log-normal. This is indicated well on the curve drawn for run N1 in Appendix IV. MMAD's for all runs are presented in Table III.

DISCUSSION

General.

The utility of this particular aerosol system is dependent primarily upon whether or not the aerosol generated is distributed fairly uniformly throughout the chamber. Thus, most of the data gathered in this project were slanted towards determining size distribution and the variation in mass concentration existing in the chamber. However, the performance of the system components, especially the three dust dispersal systems used in the course of experimentation, is also quite important and will be discussed in this section.

General Test System.

The test system as built combines several component parts which together are designed to produce a uniform dust cloud in terms of mass concentration and particle size distribution throughout the chamber. The physical size of the chamber ($\sim$ 450 liters) as well as its circular cross-sectional shape (5) is the first essential factor in producing uniform aerosol loadings especially when considering the number of simultaneous samples taken on one data run. Significant disruption of the aerosol cloud might be expected with similar sampling in a smaller chamber. This size also allowed for a relatively large volume of air to be moved through the chamber and still retain low flow velocity, so that sampling could be accomplished from an essentially static environment without concern for isokinetic sampling. Thorough cleaning of the chamber when desired is easily accomplished, as sufficient room is available inside for a full-grown man, with easy access through the top.

The mixing assembly located in the conical transition piece in the bottom of the chamber allows for optimal mixing in a small area. This is accomplished by allowing the aerosol stream and clean dilution air to enter the assembly through opposite inlets placed tangentially to the outer edge of the assembly. This approach has

been used in other test systems and exposure chambers (5); however, the mixing assembly has conventionally been located at the chamber top with the exhaust port below (5,6).

Manipulation of the valves associated with the pump easily controls the static pressure in the system. This allows for testing to be accomplished without fear of leaks, a factor of prime importance when using moderately hazardous dusts.

Two other components of the test system, both located between the aerosol generating device and the chamber,essentially eliminate two of the major difficulties often encountered with dry dust dispersion. The first occurs when fine particles packed closely together agglomerate and tend to resist separation. The dilution cylinder uses 56 liters/minute of clean air which enter through four tangential inlets resulting in a visible cyclonic mixing action of the aerosol stream. Presumably, sufficient energy is supplied in this airstream to disperse many of the agglomerates to their component particles. Others, not dispersed, fell to the bottom of the cylinder. Thus, artifically large dust particles are not introduced into the sampling chamber. Both MIN-U-SIL 15 and Attacote, the two dusts tested with the Fluidizing Generator, left considerable dust masses in the dilution cylinder with each run, apparently relatively large particles or agglomerates. This feature may also be important when the Wright Dust Feed is used as the unit disperses dust from a dense compact, especially in the use of extremely fine dusts (7). With the DeVilbiss Ultrasonic Nebulizer, the dilution cylinder probably served only to allow additional time to dry the aerosol before entering the sampling chamber. The cylinder sides and bottom were coated with the liquid uranine solution at the end of each run. The dilution cylinder's only drawback is quite minor. Thorough cleaning of the apparatus, though not absolutely necessary between each data run, can be accomplished only by disassembly.

A second difficulty common with dry dust dispersion is the production of particles of a high electrostatic static charge. This problem is negated by the introduction of a radioactive β source located in line between the dilution cylinder and the mixing assembly. Presumably particles are sufficiently discharged, as no effect on sampling results were apparent. Again this component of the test system is most important with dry aerosols - those produced by the Wright Dust Feed and Fluidizing Generator.

<u>Aerosol Cloud Uniformity</u>.

The results tabulated in the testing of this system and summarized in Table II indicate that the aerosol cloud is dispersed quite uniformly throughout the chamber. The smallest differences in mass concentration throughout the testing were found at the equivalent peripheral ports 1 through 8. Differences, between the top sampling ports T1, T2, and T3 were generally only slightly higher. For example in run F2, $\overline{x}$ was 12.25 mg/m^3 and its standard deviation (s) was 0.26 mg/m^3. The top ports gave an $\overline{x}_T$ of 10.82 mg/m^3 was s = 0.46 mg/m^3. If all ports, side and top, are includ-

ed, the mean concentration is 11.86 mg/m^3, and s = 0.74 mg/m^3, giving a coefficient of variation of 6.2%. Thus, mass concentration samples collected from all ports can be considered reasonably equivalent. Samples collected with the spiral filter arrangement from ports 1 through 8 had the largest variance. Even for these runs, however, the maximum coefficient of variation was only 6.4% (run F1). Results from this run indicated a slight drop-off in concentration of the dust Attacote with distance away from the chamber side (Figure 12). Only one run (M7) shows uncharacteristically large standard deviations and variances between side and top sampled ports ($\bar{x} = 9.35 \pm 1.68$ mg/m^3; $\bar{x}_T = 12.50 \pm 1.17$ mg/m^3). However, this run was the first analyzed spectrophotometrically and erroneous results are likely due to inexperience in using the method.

The aerosol clouds had only a slight tendency to separate by size within the chamber. Seemingly, this phenomenon increased with the MMAD of the individual dust being tested. This can be easily seen by examining the sizing curves in Appendix II in which an Andersen sample was collected at two different chamber heights (runs N1, W1, F3, and F4). Routinely the first Andersen sample was collected through port M1; the second, when added, through port 1. No appreciable difference in size distribution between these ports was found for the uranine aerosol (N1) or for the coal dust (W1). However, Attacote (F3 and F4) runs showed noticeable variation, with MMAD's at upper and lower ports of 4.5 and 5.5 μm, and 4.7 and 6.5 μm, respectively. This slight settling of larger particles might be expected in light of the low upward flow velocities in the chamber as previously mentioned.

DeVilbiss Ultrasonic Nebulizer: The nebulizer was by far the most predictable generator tested in terms of producing a steady flow of aerosol into the chamber. This can be easily seen by examining Figure 13, the record of aerosol concentration with time in the chamber for run N5 as monitored by the Sinclair-Phoenix aerosol photometer. This record typifies the type of consistency in output of the Nebulizer for all its runs. Mean mass concentrations were found to vary inversely with flow through the chamber (Figure 14). The particle size generated from a particular concentration of solution is predicted by the equation (8)

$$\text{Diameter of Aerosol} = \text{Diameter of droplet} \sqrt[3]{\frac{\text{solution concentration}}{\text{particle density}}}$$

As predicted by this equation, the MMAD for run 8 (7% uranine) was higher than the MMAD's for runs N1 through N5, done with a 1.75% uranine solution. Particle size distributions were not strictly log normal as can be seen by examining the curves for runs N1 through N5 in Appendix II. This was expected and is a characteristic feature of Nebulizer output (9). Less aerosol was generated for those runs which used a more concentrated solution (M7 and M8). This phenomenon apparently is due to the upper limit of the droplet size which may form and still break the surface tension of the solution in order to enter the airstream.

DUST CONCENTRATION VS. DISTANCE
FROM SIDE WALL IN RUN F1

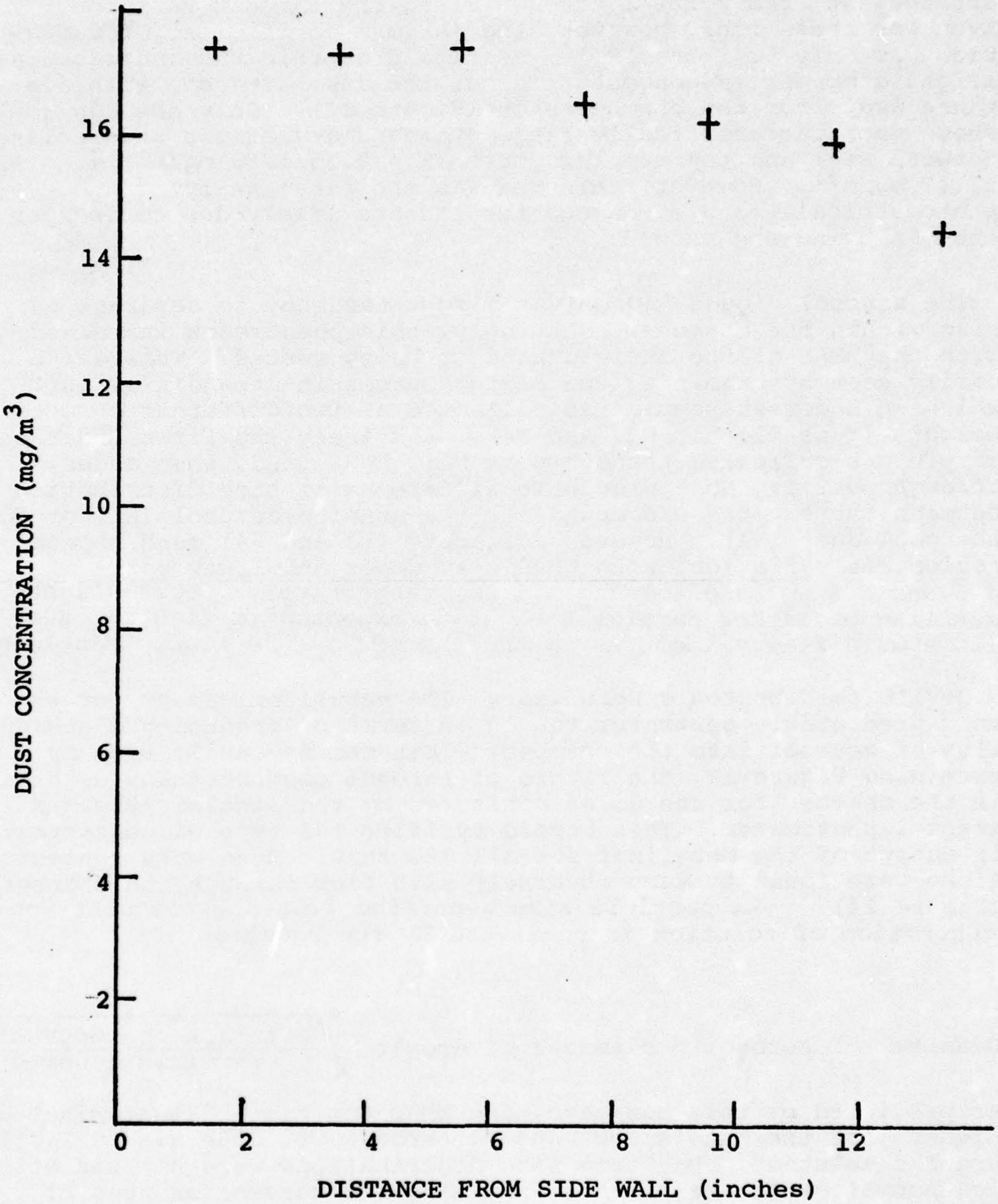


Figure 12

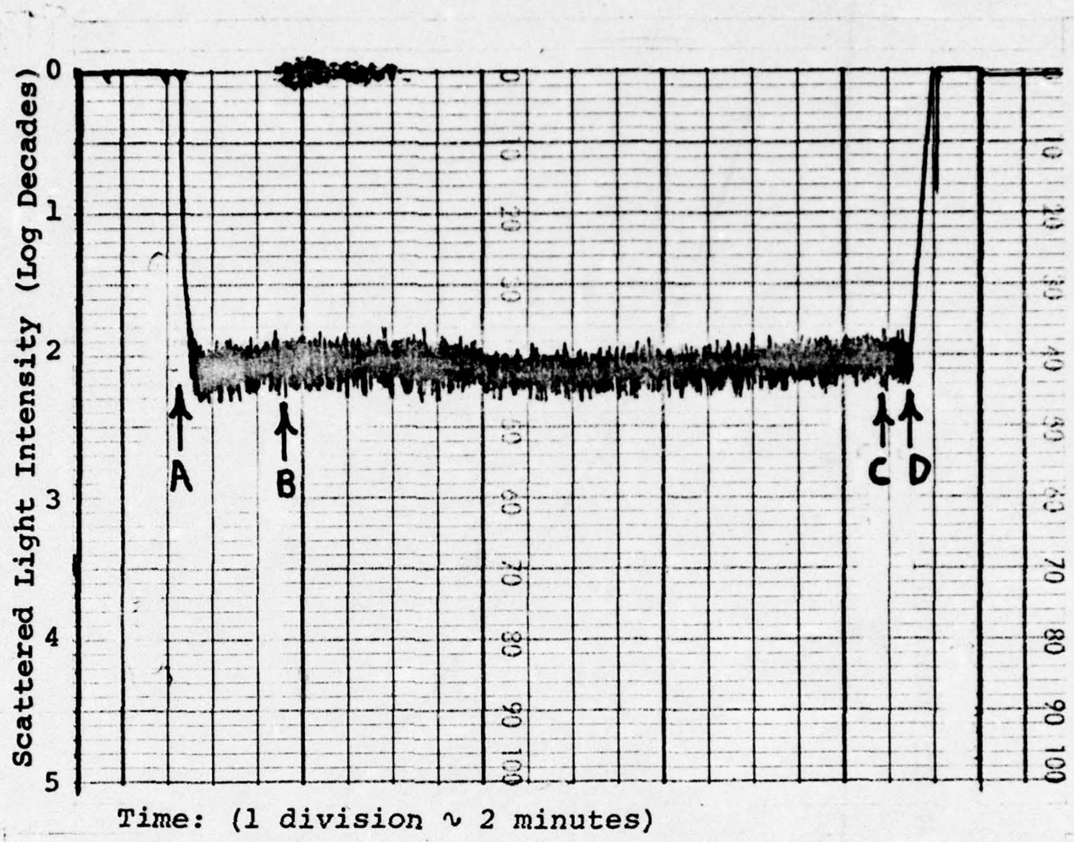


Figure 13. Sinclair - Phoenix recording of concentration vs. time for run N5. (A) Indicates Generator Start-up
(B) Start of Sampling
(C) End of Sampling
(D) Generator Shut-down

FLOW VS. CONCENTRATION
FOR RUNS N1 THROUGH N5

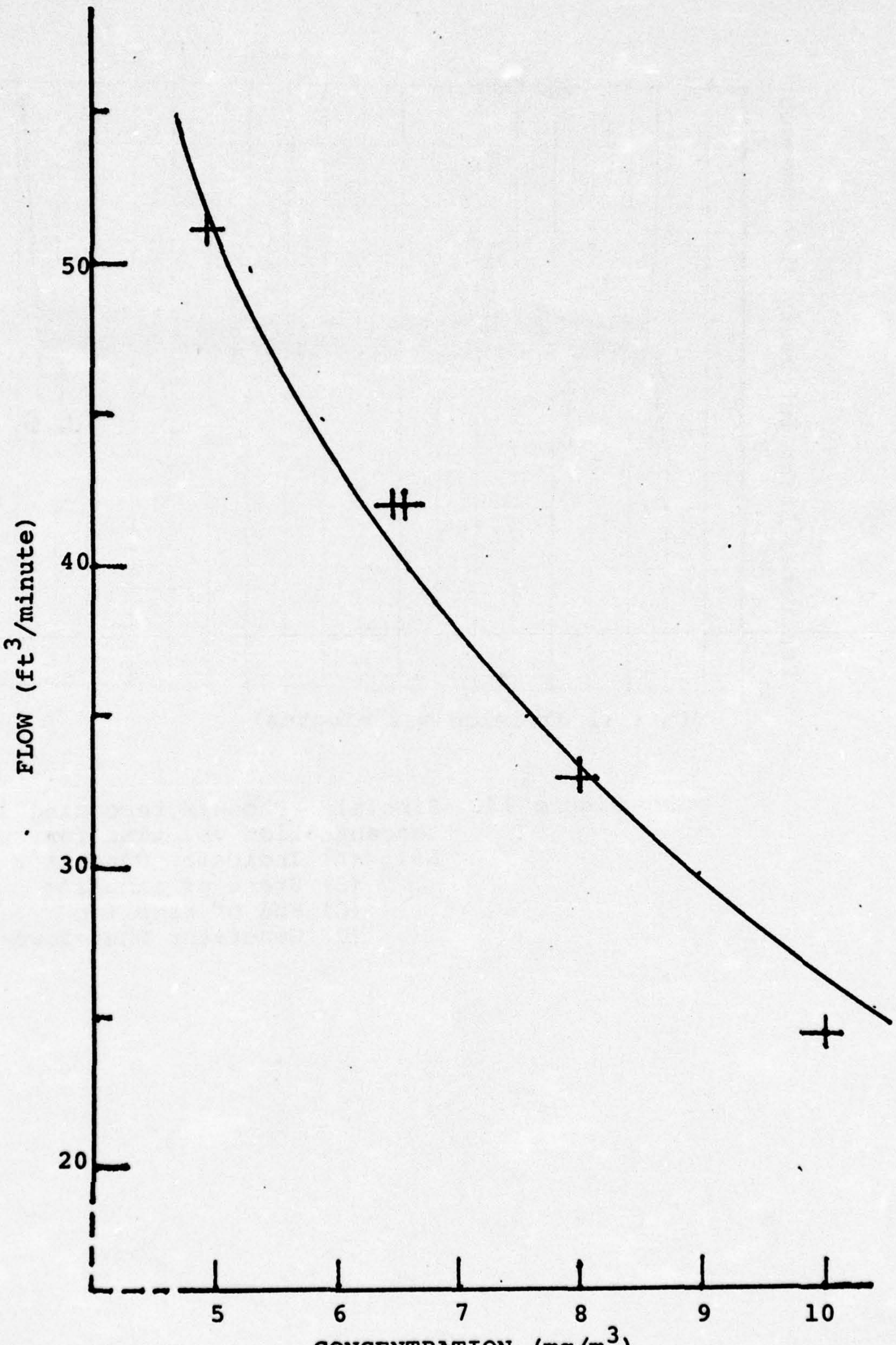


Figure 14

limit of the droplet size which may form and still break the surface tension of the solution in order to enter the airstream.

One result which became apparent while analyzing uranine filter samples was the noticeable differences which existed in mass concentration determination between weight and spectrophotometric methods. Samples analyzed by weight in run M9 were, on the average, 8-10% higher than those same samples analyzed spectrophotometrically. Similar results were obtained for run M8. This can be attributed to one (or both) of the following: 1) upon dilution for spectrophotometric determination, some of the uranine remained bound up in the glass fiber filters and never entered the dilution solution resulting in lower than actual results, and 2) the very water soluble uranine aerosol deposited on the filter papers picked up considerable moisture resulting in higher than actual weight determinations. Although either one of these can adequately explain the variance between methods, neither was investigated.

Wright Dust Feed: Dust feed into the aerosol chamber from the Wright Dust Feed Mechanism was by far the most uneven and unpredictable of the three generation systems tested. As seen in Figure 15, the Sinclair-Phoenix record of dust concentration in the chamber for run W4, dust generation was characteristically uneven and cyclic. Although the Wright Dust Feed has been used by others successfully in providing a wide range of aerosol concentrations by varying air flow and dust cylinder rotation rate (10), dust output on a short-term basis (30 minutes) in our test situation was not at all predictable. Fairchild et al. (11) found that startup of the unit with a new dust plug produced the highest instability in mass concentration output and lasted up to two hours. We produced comparable results as indicated on Figure 16, the Sinclair Phoenix trace of mass concentration upon starting the unit with a new dust plug. Restarting the unit with the same plug resulted in similar but less severe variation lasting up to 30 minutes.

Since sampling in this procedure normally lasted 30 minutes, and no more than 5 to 10 minutes separated generator start-up and sampling start-up, the rather large variations in output are not at all surprising.

Although the unit has the disadvantage of not being able to predict within a reasonable range the concentration being generated by the Wright Dust Feed upon start-up of the unit, it does offer several advantages. It can be used with a wide variety of test dusts while offering considerable ease of operation. In addition, its tendency to produce a charged aerosol stream with some agglomerates is eliminated in this system as previously discussed.

Fluidizing Generator: Dust feed into the aerosol chamber from the Fluidizing Generator characteristically exhibited a curve as shown in Figure 17, again a trace of mass concentration with

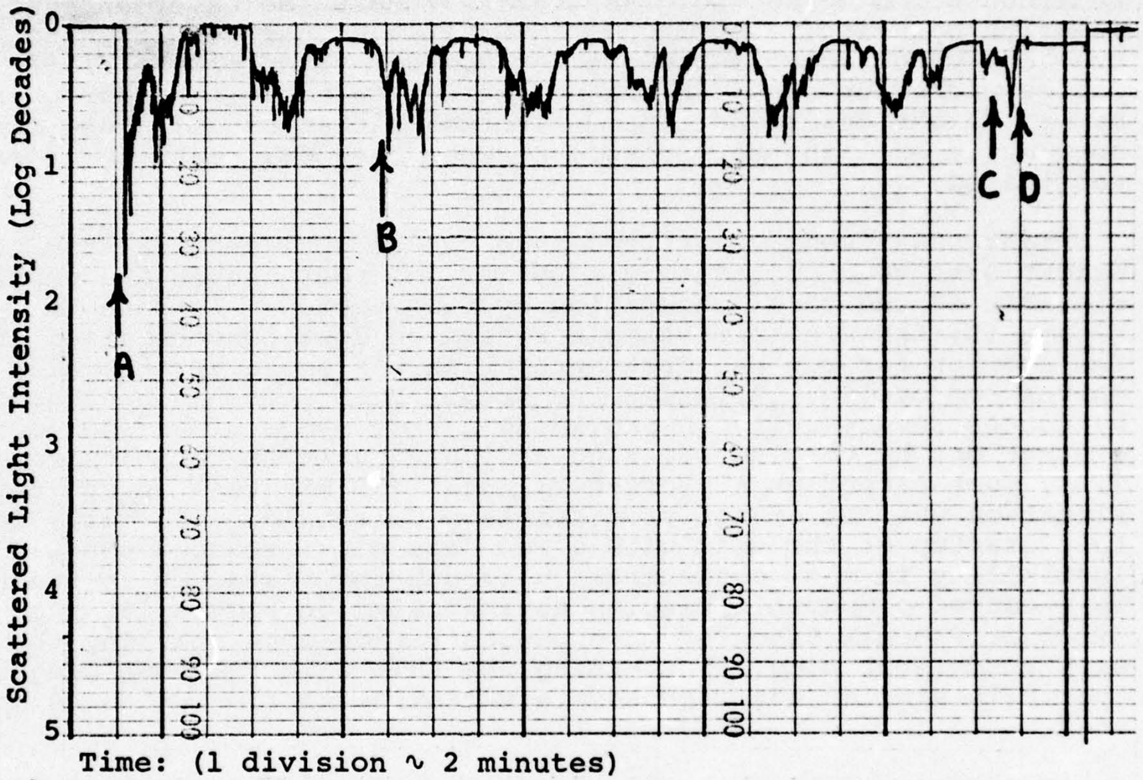


Figure 15. The Sinclair - Phoenix Recording of Concentration vs. time for run W4. (A) Indicates Generator Start-up (B) Start of Sampling (C) End of Sampling (D) Generator Shut-down

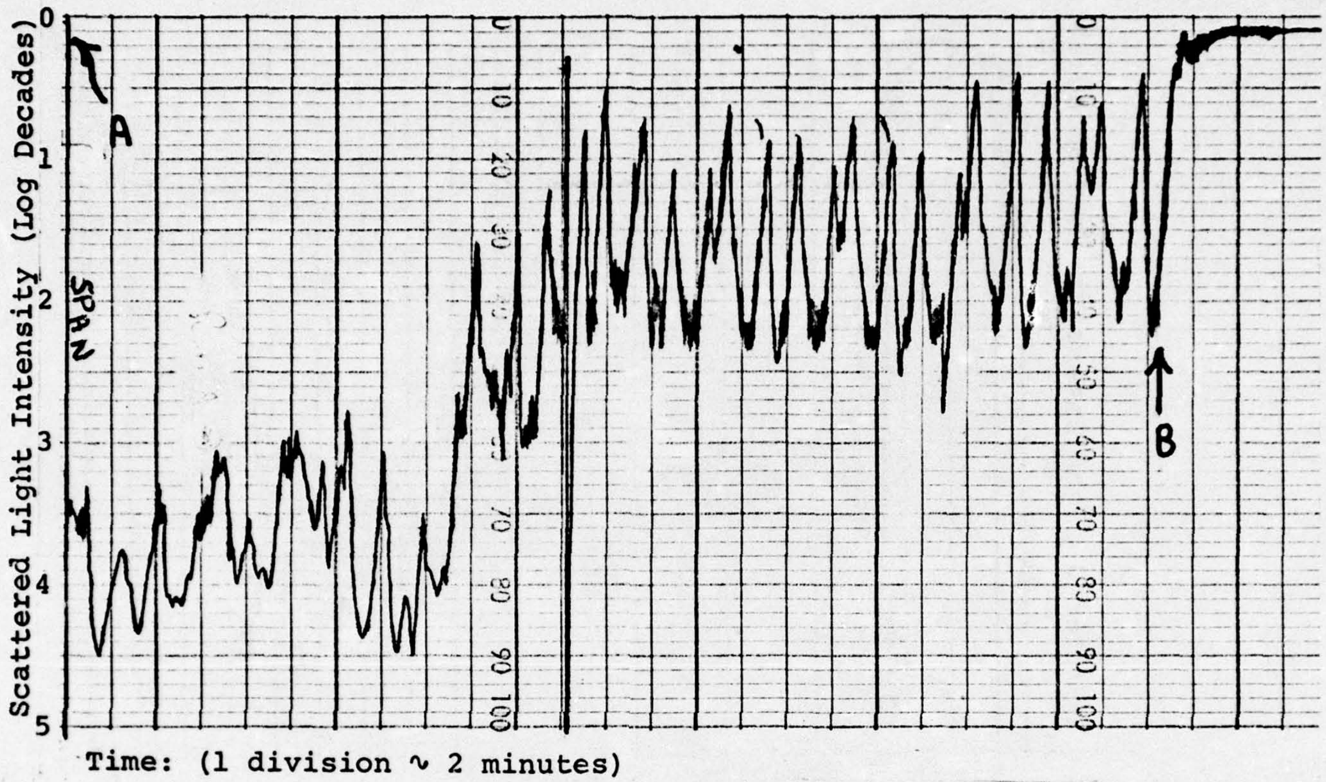


Figure 16. Sinclair- Phoenix Recording of concentration vs. time for the Wright Dust Feed with a new dust plug. (A) Indicates Generator Start-up (B) Generator Shut-down

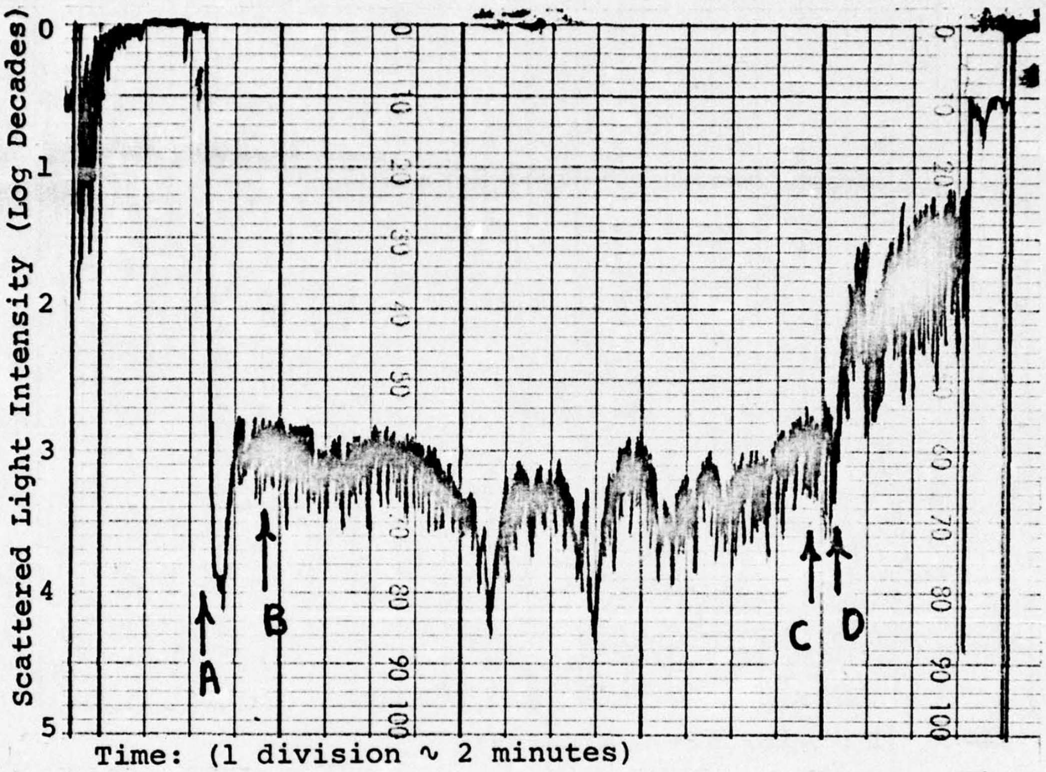


Figure 17. Sinclair - Phoenix Recording of concentration vs. time for run F5.
(A) Indicates Generator Start-up
(B) Start of Sampling
(C) End of Sampling
(D) Generator Shut-down

time as monitored by the Sinclair-Phoenix (run F5). Generation was relatively stable over the 30-minute sampling period. The initial peak routinely associated with starting the generator was most likely due to a near instantaneous blow-off of the extremely fine particles in the dust load into the chamber. The rotating wiper blades moving along the inside of the fluidizer continuously knocked compacted dust from the unit's periphery back into the fluidizing blade aiding in steady output. Small peaks on the Sinclair-Phoenix trace during the course of the run are likely due to dust compacts falling from the inside top of the Fluidizing Generator into the spinning blade momentarily increasing generator output. Generator output was found to be related to motor speed. With a 50 gram dust load of either MIN-U-SIL 15 or Attacote, the generator was inoperable when less than 10 v were applied to the blade's motor as stalling conditions were reached. Varying bottom feed air between 500 and 2000 cc/min. had no visible effect on generator output. Reduced output was noticed when bottom air was below 500 cc/min. In terms of continuous and even output, the unit was found to operate less efficiently with the MIN-U-SIL 15 as successive runs were accomplished. This was attributed to the dust picking up moisture over a period of several weeks thus increasing agglomeration of particles in the initial dust loading and hindering an even dispersal (12). This resulted in large variations in output with time as seen in run M5 (Figure 18). An occasional problem with momentary stalling of the wiper blades was encountered several times. This resulted in an initial drop in dust concentration within the chamber followed by more severe peaks and valleys as seen in run F2 (Figure 19).

Perhaps the major advantage of this generating system is that it is easily used with any dry dust and is especially advantageous for light, fluffy dusts which would tend to resist compaction into a dust plug. The unit was as easy to operate as either of the other two more conventional units tested. However, cleaning the unit as constructed - a step necessary after each run - was not particularly easy. The unit has to be disassembled, wiped out, and vacuumed to avoid a buildup of dust under the fluidizing blade. Failure to do this is likely to lead to stalling of the blade and/or operation of the blade at lower RPM's than expected. Failure of dust concentration versus flow to follow a strict inverse relationship was attributed to large dust particles settling in the chamber and not to the performance of the unit itself.

Cyclone Collection.

Although the collection of dust samples which passed through cyclones constitutes only a small portion of the data gathered for this report, its contribution to the data is important. When the testing of cyclones was started, it was felt that the chamber system was performing up to expectation. With this in mind, the cyclones were tested only as an indication of what the test system is capable of accomplishing. Because of the variation in port size and location, many types of sampling equipment, sampling simultaneously, can be mounted in the chamber. With a knowledge

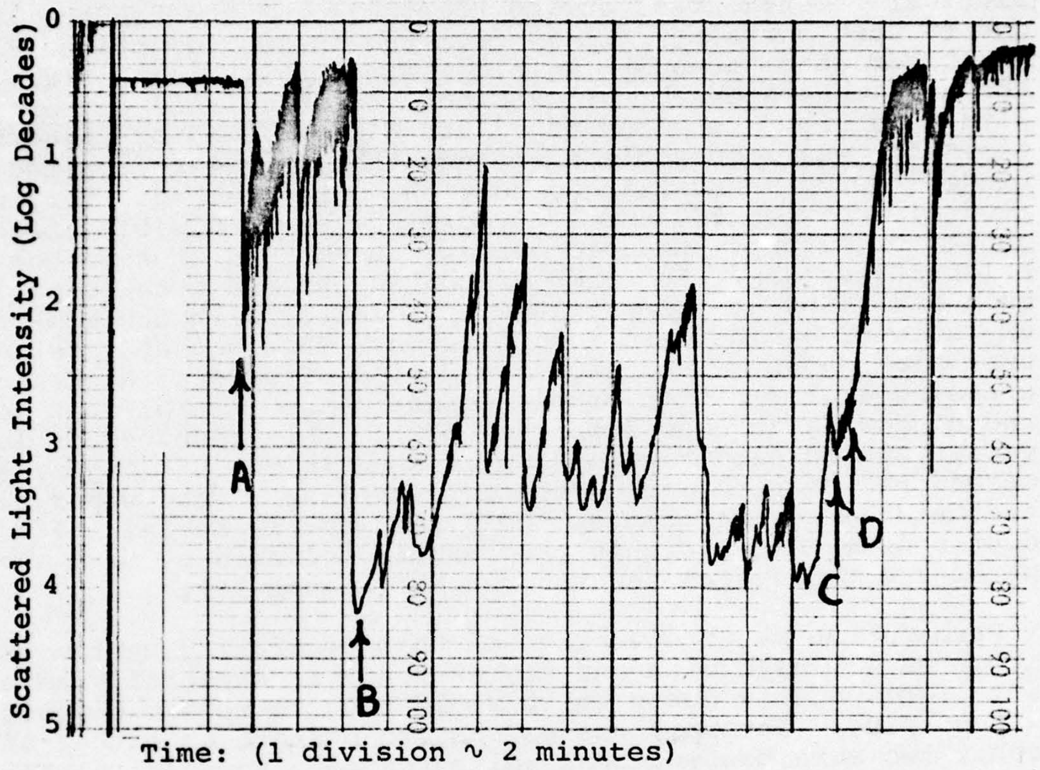


Figure 18. Sinclair - Phoenix Recording of concentration vs. time for run M5. (A) Indicates Generator Start-up (B) Start of Sampling (C) End of Sampling (D) Generator Shut-down

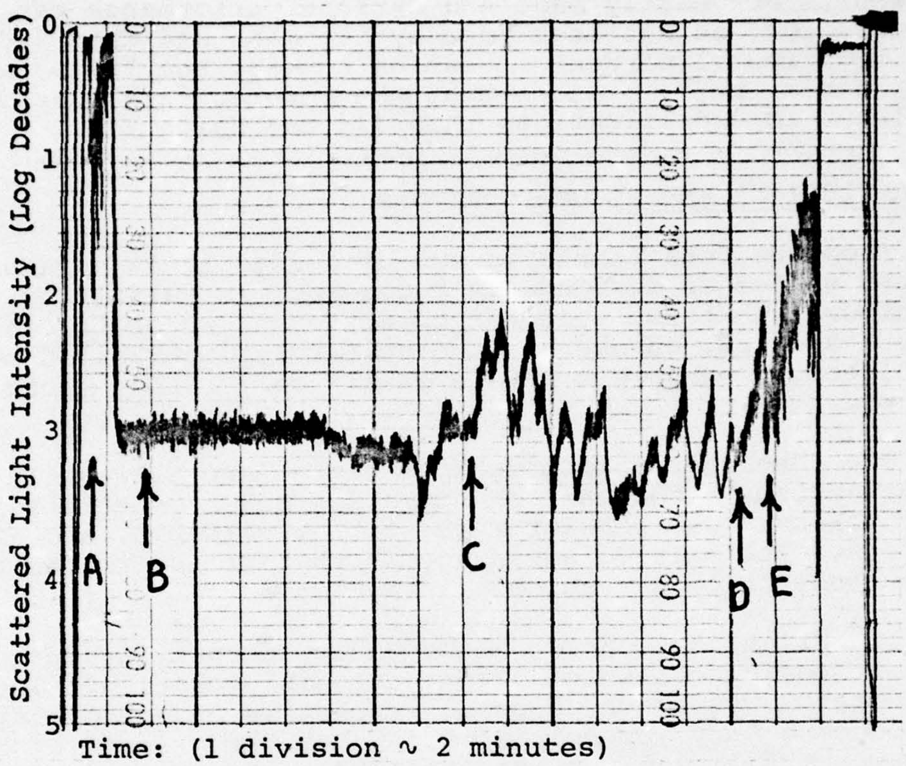


Figure 19. Sinclair - Phoenix Recording of concentration vs. time for run F2. (A) Indicates Generator Start-up
(B) Start of Sampling
(C) Indicates the Point at which wiper blades stalled
(D) End of Sampling
(E) Generator Shut-down

of mass concentration and aerodynamic properties of the dust cloud, calibration of sampling equipment can be easily accomplished. Comparisons between sampling equipment, as with the Unico 240 and Aerotec "3/4", are then readily made. Considering the size distribution of the dust Attacote in runs F4 and F5, it can be estimated that if each cyclone was performing optimally, as prescribed by the ACGIH curve, they each would have passed 39% of the dust to the respective filters (13). Knowing this, comparison to optimum results are easily made and cyclone performance can be critically evaluated, as has been done by Lippmann and Chan (14). From this estimation of percent retention to meet the "respirability" criteria, it is obvious that the Aerotec "3/4" performed much closer to specifications than did the Unico 240.

CONCLUSIONS AND RECOMMENDATIONS

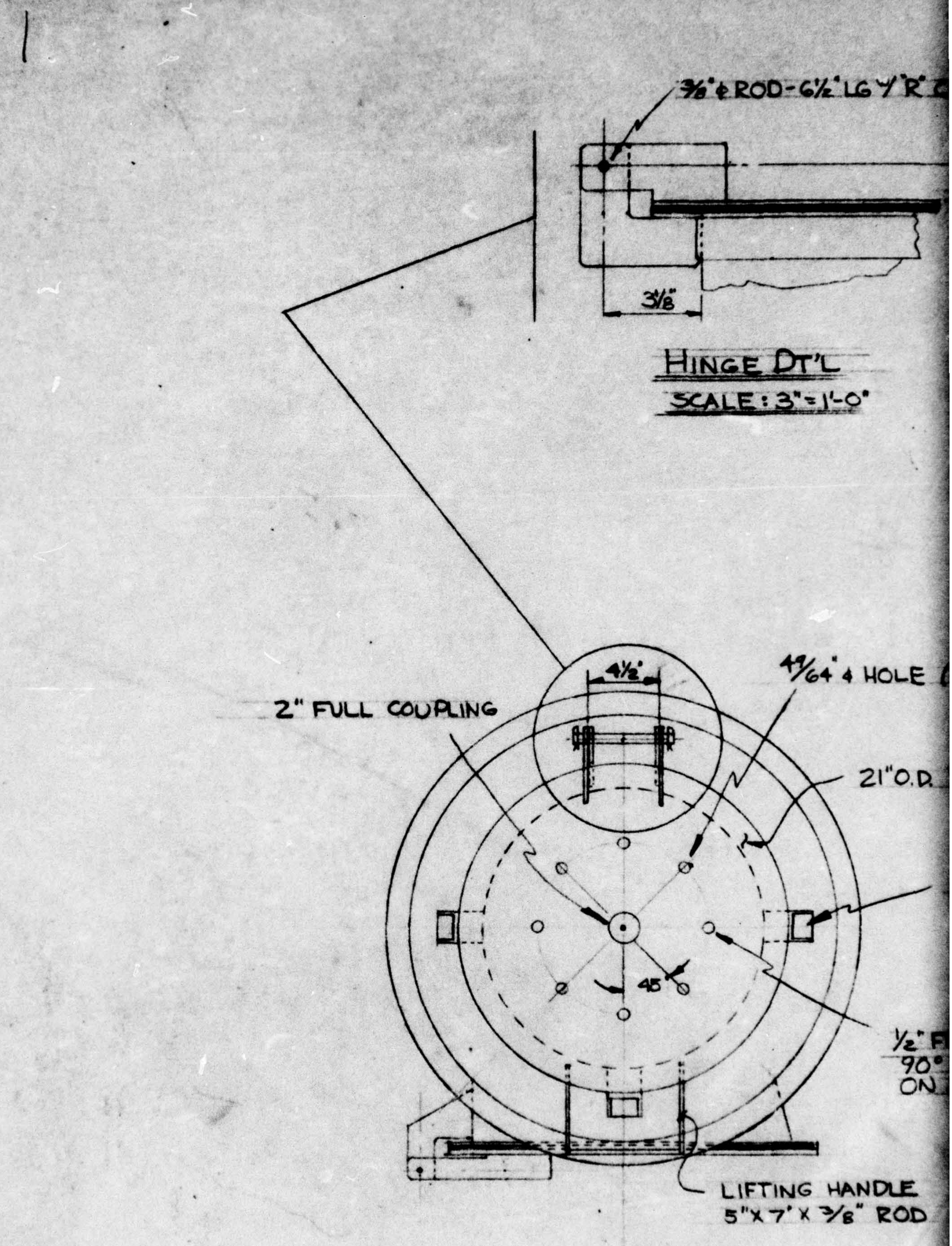
From the data tabulated and discussed it is apparent that the test system as designed is successful in fulfilling its primary purpose; that is, a number of different aerosols can be generated into the test chamber and be uniformly distributed so that collection equipment can be easily calibrated, checked and compared.

The three generation methods tested are all easily adapted to the system, although each has a few minor restrictions and/or drawbacks. The nebulizer is stable, reliable, and easy to operate. Its only disadvantage is that it is limited to producing aerosols which are soluble in a liquid.

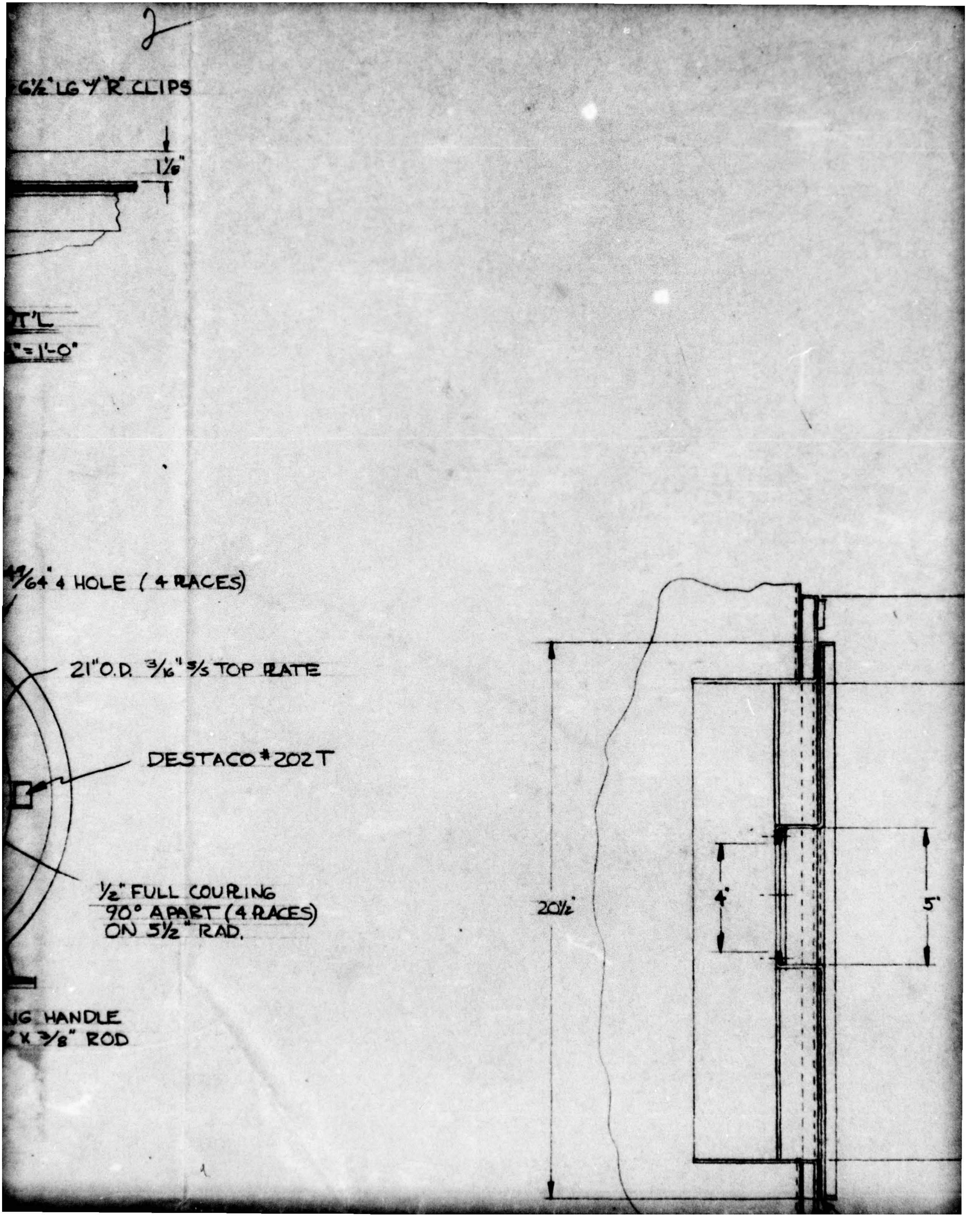
The Wright Dust Feed, although its output is unpredictable over short periods of time, offers ease in operation. The Fluidizing Generator was shown to be an innovative and promising method of producing many aerosol types in that the process of dispersion in no way artificially treats the dust. However, predictability in rate of generation for any one dust loading must be experimentally determined. Cleaning the system also poses a minor problem.

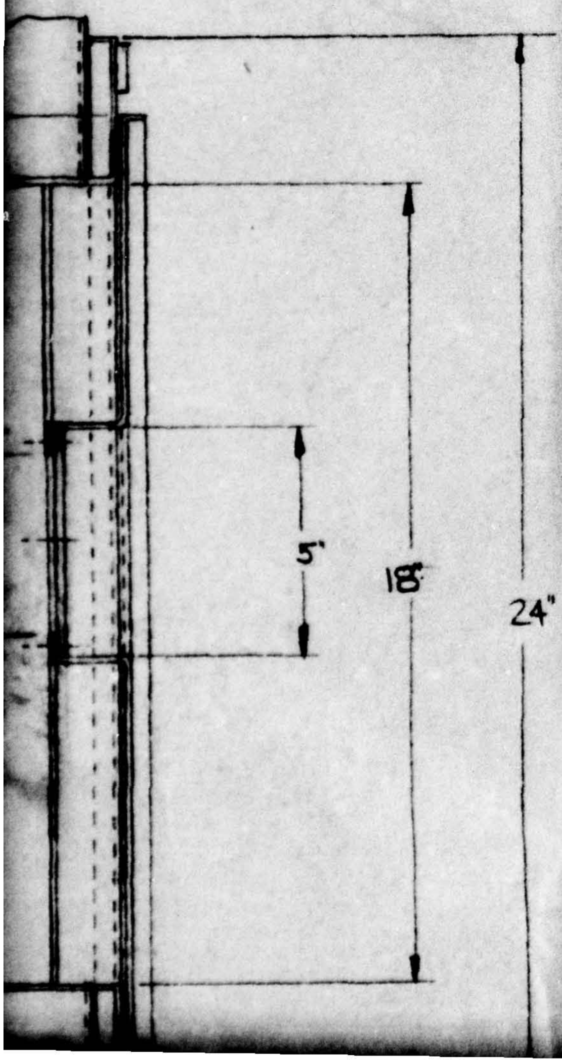
For best results in comparing collection equipment, sampling from geometrically equivalent ports is recommended. Comparisons can be made when collecting from non-equivalent ports for example, side and top, but slightly higher variations should be expected.

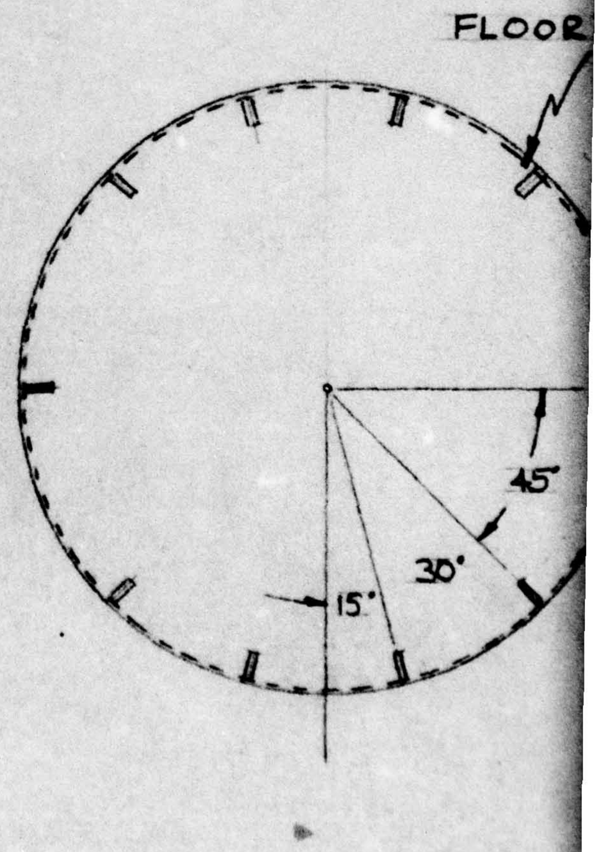
Monitoring the test system in terms of short-term mass fluctuation proved to be a valuable tool in analyzing the performance of the system, particularly the generation device. Therefore, it is desired that some instrument capable of near instantaneous relative concentration readout be used when operating the system. Several instruments have been used successfully to perform this function in other tests (11). However, the Sinclair-Phoenix aerosol photometer was quite successful in meeting the needs of this system and is highly recommended.



3/8" ¢ ROD-6½" LG W/ "R"
3⅛"
HINGE DT'L
SCALE: 3"=1'-0"
4½"
49/64" ¢ HOLE
2" FULL COUPLING
21" O.D.
45°
½" F
90°
ON
LIFTING HANDLE
5"X 7' X 3/8" ROD

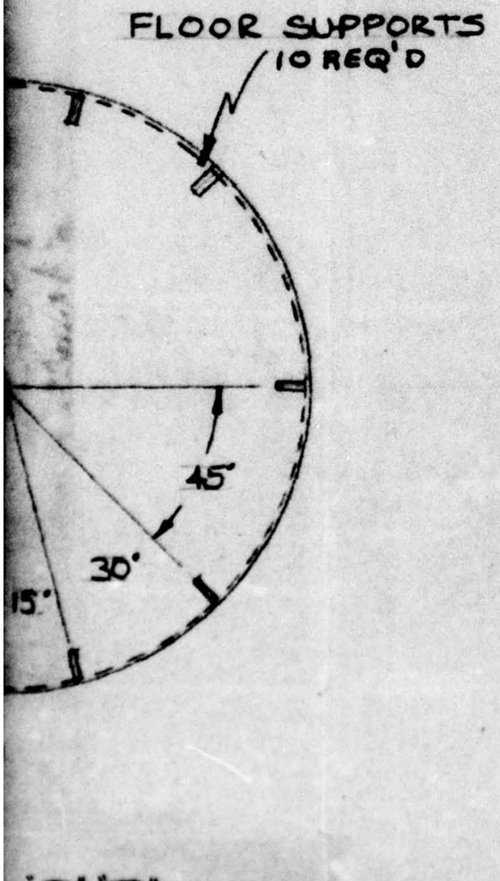

2
6½" LG W/ "R" CLIPS
1⅛"
T'L
" = 1'-0"
47/64" ⌀ HOLE (4 PLACES)
21" O.D. 3/16" S/S TOP PLATE
DESTACO #202T
½" FULL COUPLING
90° APART (4 PLACES)
ON 5½" RAD.
NG HANDLE
" X 3/8" ROD
20½"
4"
5"



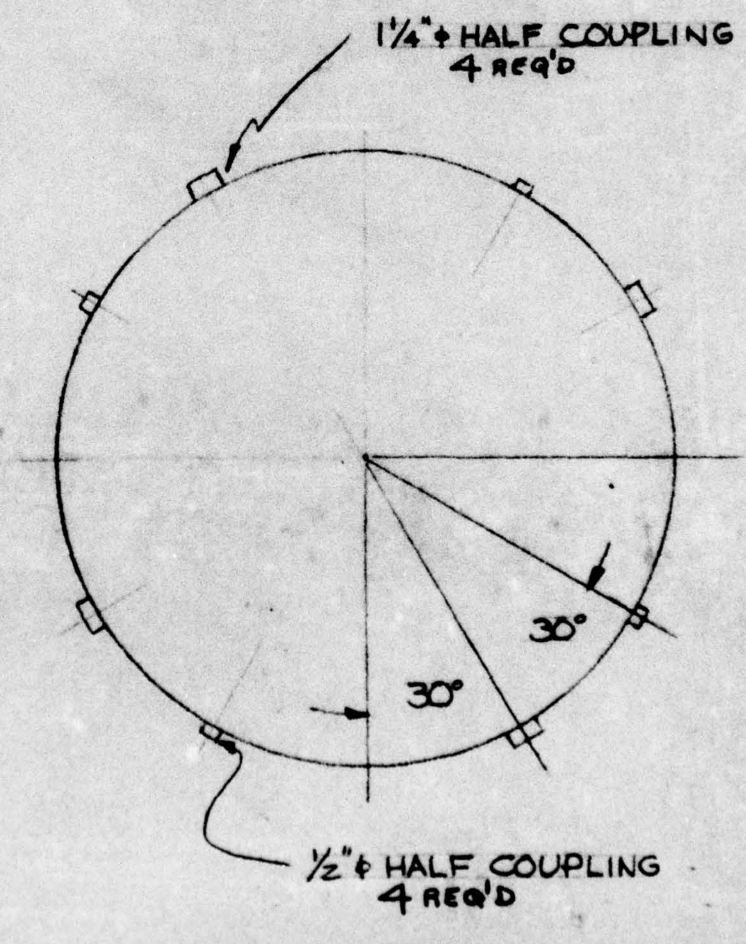


SECTION "D"-"D"

4

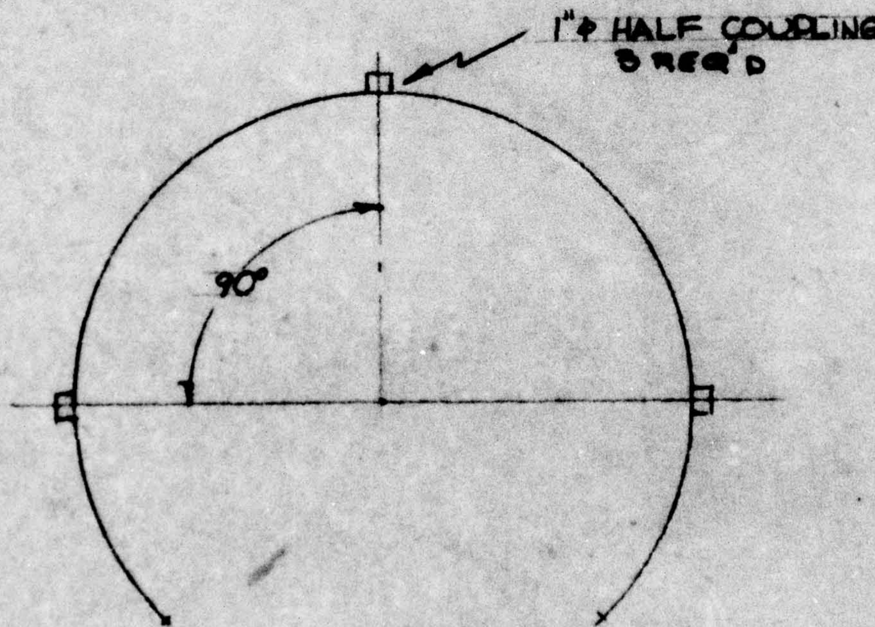


"D"-"D"



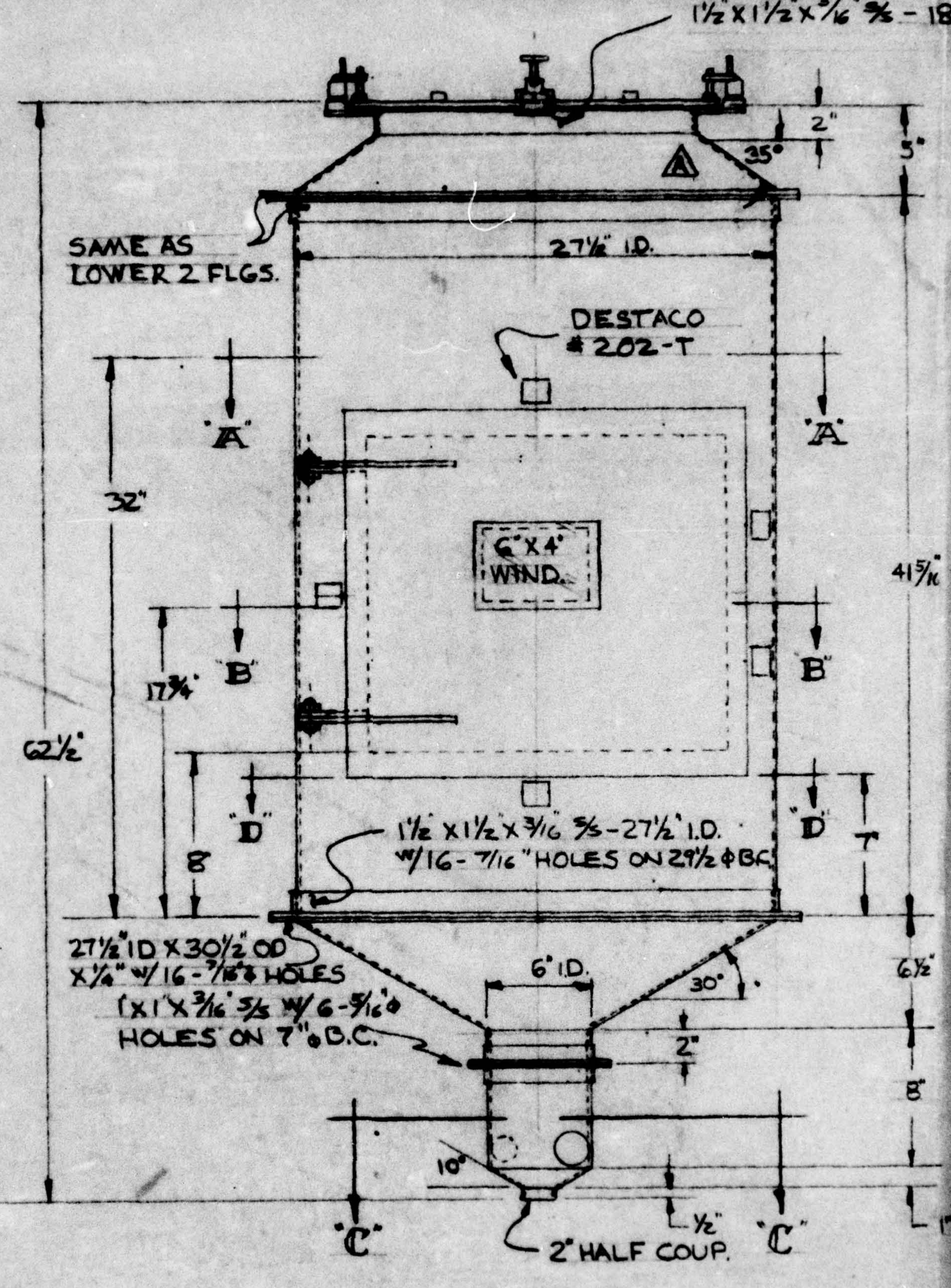
SECTION-A-A

5



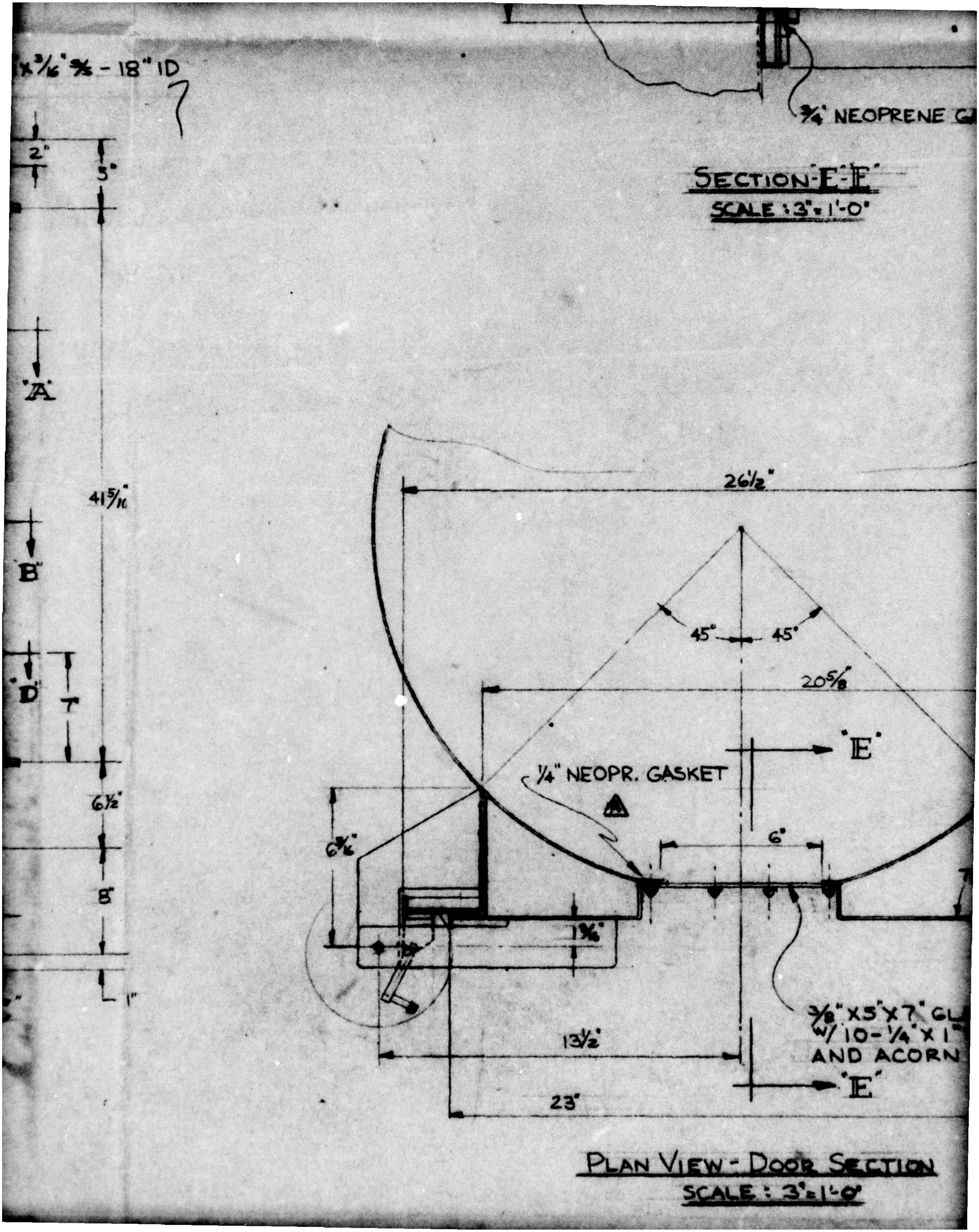
SECTION-"B"-"B"

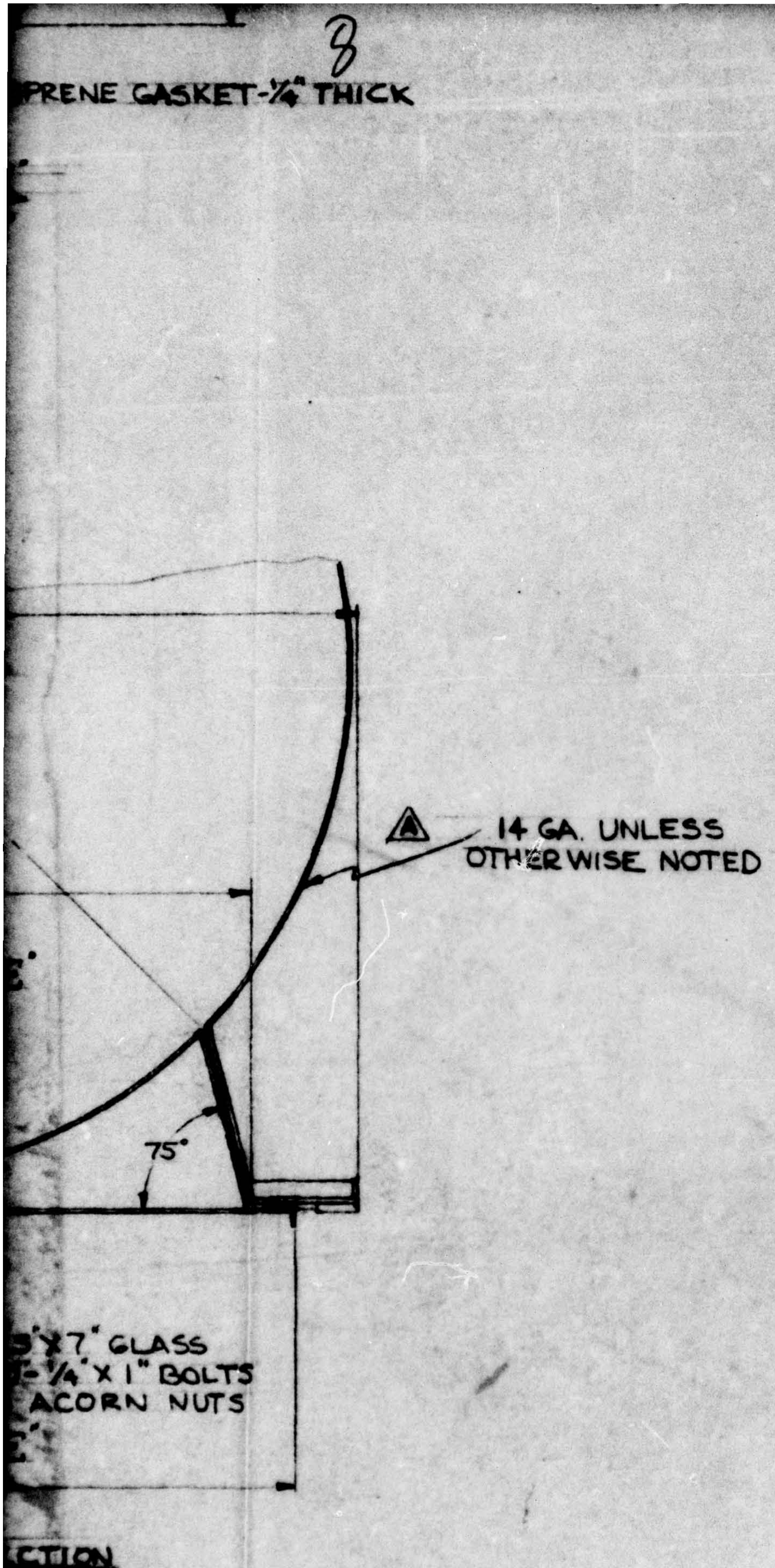
6

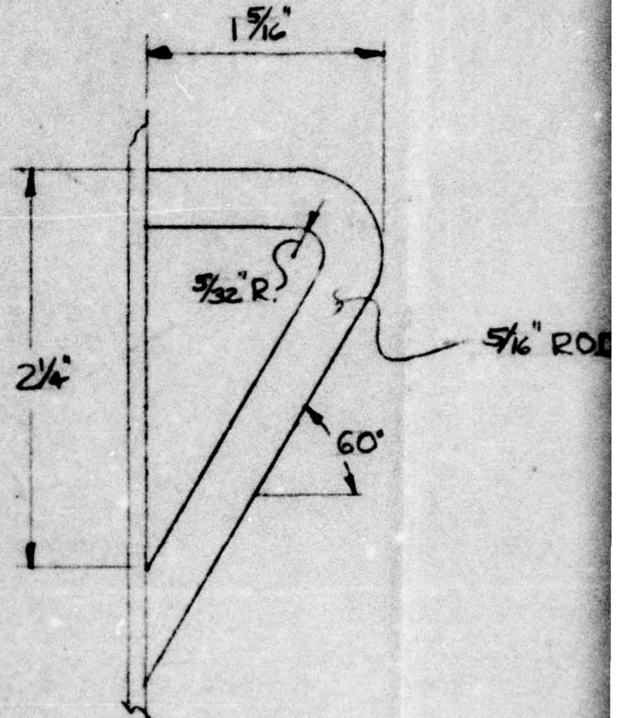


FRONT ELEVATION

SCALE: 1½" = 1'-0"


x 3/16" 9/8 - 18" ID
3/4" NEOPRENE G
SECTION "E"-"E"
SCALE: 3" = 1'-0"
2"
5"
"A"
41 5/16"
"B"
"D"
7"
6 1/2"
8"
1"
26 1/2"
45°
45°
20 5/8"
"E"
1/4" NEOPR. GASKET
6 3/16"
6"
1 3/16"
3/8" X 5" X 7" GL
W/ 10 - 1/4" X 1"
AND ACORN
13 1/2"
23"
"E"
PLAN VIEW - DOOR SECTION
SCALE: 3" = 1'-0"

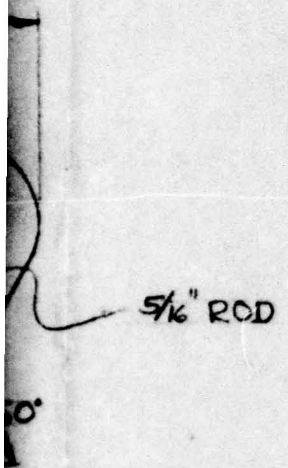


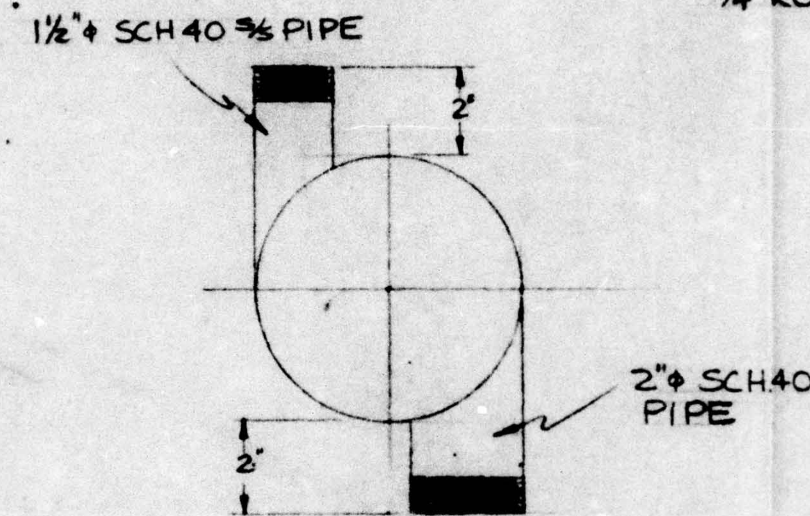


FLOOR SUPPORT-(10) REQ'D
FULL SIZE

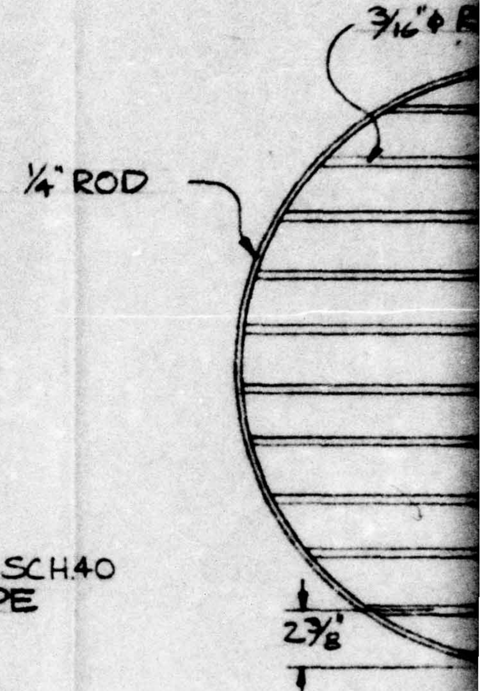
NOTE: ALL MATER
ALL BOLTE
HAVE NEO

9





SECTION-"C"-"C"



T-(10) REQ'D
ZE

REMOVA

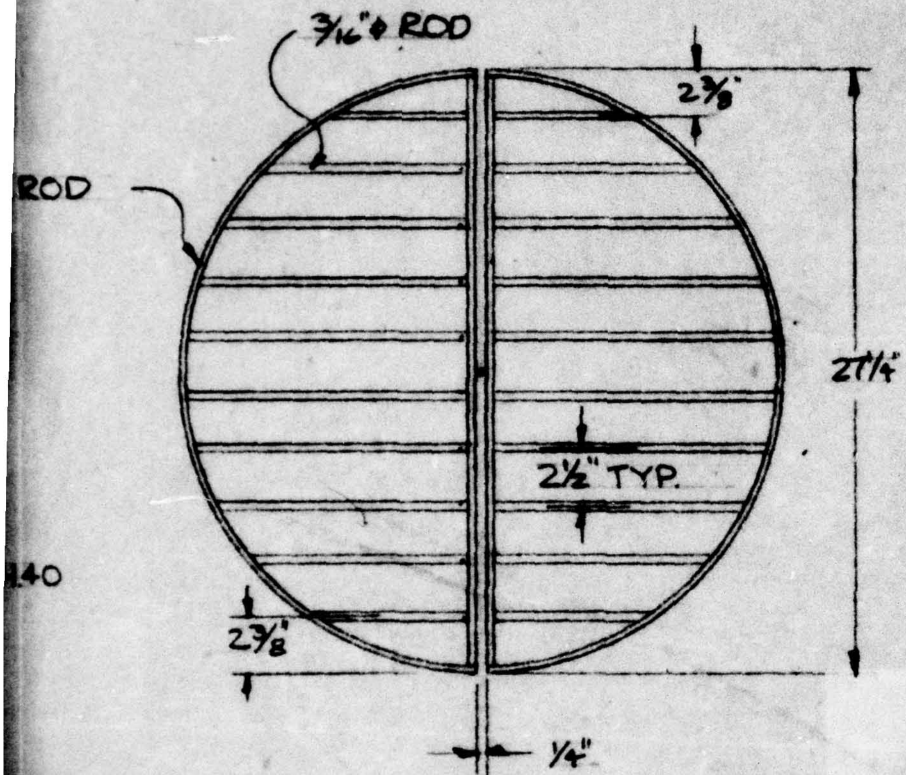
2ND GENERATION AEROSOL CHAMBE
UNIVERSITY OF CINCINNATI

S.O. K-1470

NOTICE
THIS DRAWING IS OUR PROPERTY AND IS SUBMITTED ON THE CONDITION THAT THE PLANS AND DESIGNS PROPOSED THEREIN BE HELD CONFIDENTIAL AND IS SUBJECT TO RETURN ON DEMAND.

YOUNG & BERT
CINCINNATI, OHIO
ENGINEERS

: ALL MATERIAL TO BE T-304-2BN
ALL BOLTED CONNECTIONS TO
HAVE NEOPRENE GASKETING



REMOVABLE FLOOR DTL

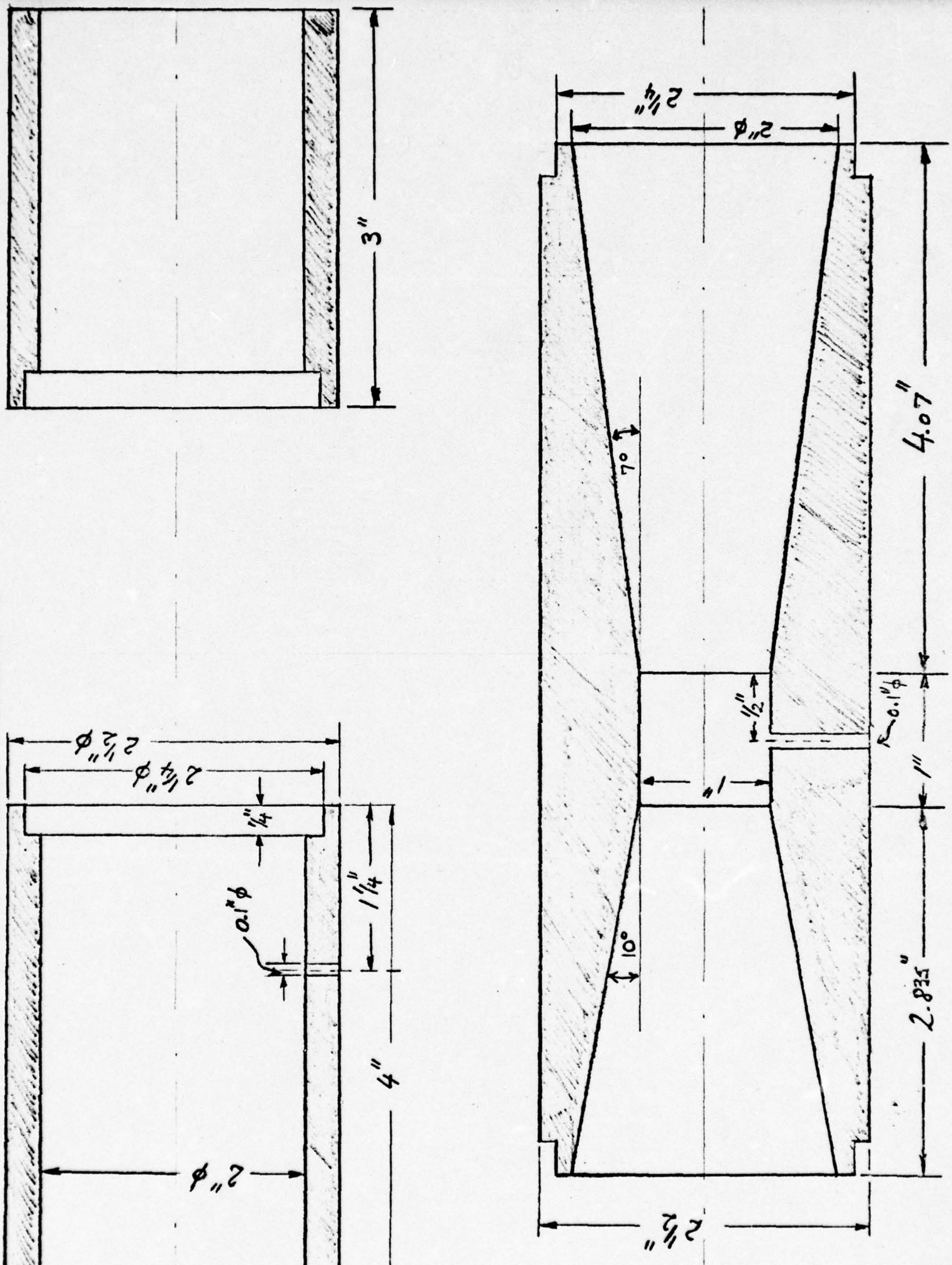
APPENDIX-I-A
Page 50

AEROSOL CHAMBER
...NNATI

UNG & BERTKE CO.
CINCINNATI, OHIO
ENGINEERS MANUFACTURERS

DRAWN D.P.	CHK.
SCALE NOTED	DATE 8-25-75
NUMBER Rx-37468	

ALUMINUM VENTURI METER

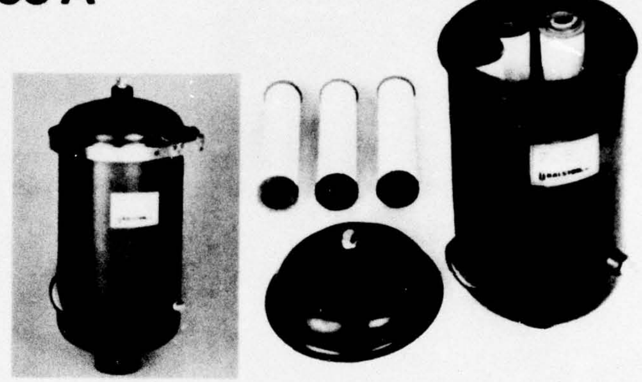


BALSTON

APPENDIX I-C

Page 52

Multiple cartridge filter housings Series A



Balston Series A Multiple Cartridge Filter Housings provide economical high efficiency liquid and gas filtration at flow capacities to 1500 SCFM in gases, or to 150 GPM with liquids.

Available in either 304 stainless steel or carbon steel, the housings accept six 2" x 9" or six 2" x 18¾" standard size Balston Microfiber filter tubes. These disposable filter tubes, composed of a unique composition of glass microfibers bonded with epoxy resin, provide filtration efficiencies as high as 99.9999+% of 0.6 micron particles in gases and 98% of 0.3 micron particles in liquids.

Each filter element is mounted on a glass-filled polypropylene support core and is individually sealed in position by means of a spring-loaded mounting assembly. Quick access to the filter chamber is provided by V-clamp and Buna-N O-ring closure. The O-ring in the clamp assembly is the only resilient seal in the filter housing. Inlet and outlet connections are 2" NPT.

For liquid filtrations, the housing is installed for outside-to-inside flow through the filter tubes, utilizing the permanent polypropylene cores for mechanical support. For air or gas filtrations, flow through the filter tubes should be inside-to-outside, permitting coalesced liquid to drain continuously from the outer surface of the filter tubes (see Technical Information Sheet TI-1).

Applications include:

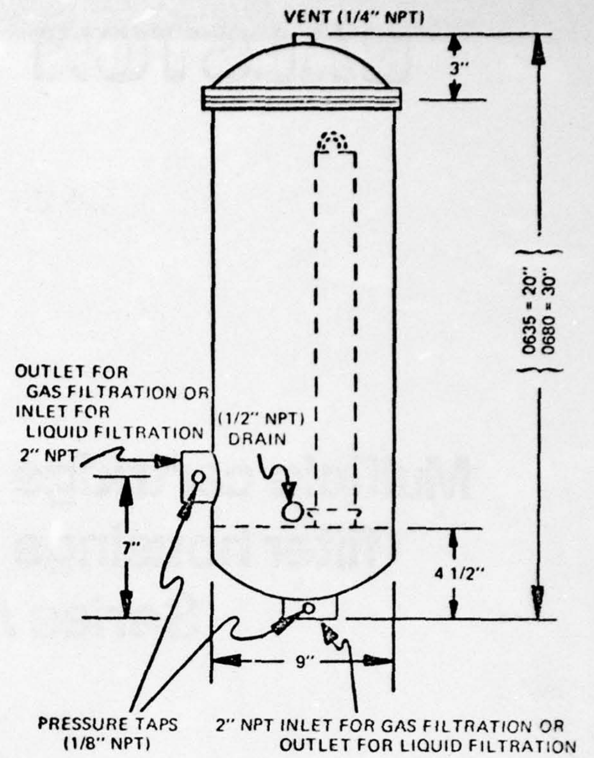
- Removal of oil, condensed water, and dirt from compressed gases at flow rates up to 1500 SCFM
- Filtration of compressed air to entire plants or large plant areas
- Vent filters to maintain the purity of liquids in large storage tanks
- Final filtration of deionized water
- Filtration of fuels at flow rates to 150 GPM
- Other demanding applications

NOTE: The Series A filters are not recommended for sterile gas filtrations in which steam-sterilization is required.

SPECIFICATIONS

Order No.	Materials of Construction	Filter Tubes Required	Filter Tube Supports Required
A-0635-C A-0635-SS	Carbon Steel 304 Stainless Steel	6 2"x 9" (200-35)	6 10Z11 or 10Z33
A-0680-C A-0680-SS	Carbon Steel 304 Stainless Steel	6 2"x 18¾" (200-80)	6 20Z11 or 20Z33

Maximum operating pressure – 150 psig
Maximum operating temperature – 275 F (135 C)
Maximum pressure differential across filter element:
70 psi for outside-in flow; 15 psi for inside-out flow
Automatic Drain (Optional) – Type 20-301 Float Drain



MATERIALS

Housing – as specified above
Filter elements – borosilicate glass microfibers bonded with epoxy resin
Support core – glass-filled polypropylene with Viton O-rings (Z11 support cores) or Buna-N gaskets (Z33 support cores)
Housing seal – Buna-N O-ring

FILTRATION EFFICIENCY

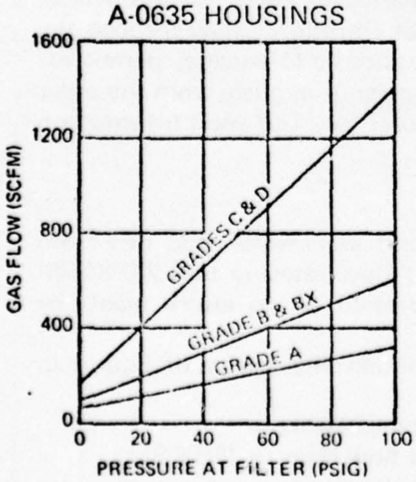
FILTER TUBE	GAS FILTRATION EFFICIENCY (Retention of 0.6 micron particle)	LIQUID FILTRATION EFFICIENCY (98% retention particle size)
Grade D	90.0%	25 microns
Grade C	91.0%	8 microns
Grade B and BX	99.95% (1)	2 microns
Grade A	99.9999+%	0.9 micron
Grade AA	99.9999+%	0.3 micron

(1) For more detailed information, see Bulletin TI-1A

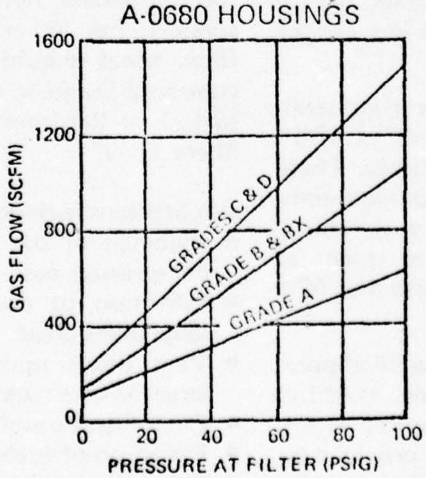
FLOW RATES

GAS FLOW at 2 PSI pressure drop
NOTE: FLOW RATE IS PROPORTIONAL TO PRESSURE DROP

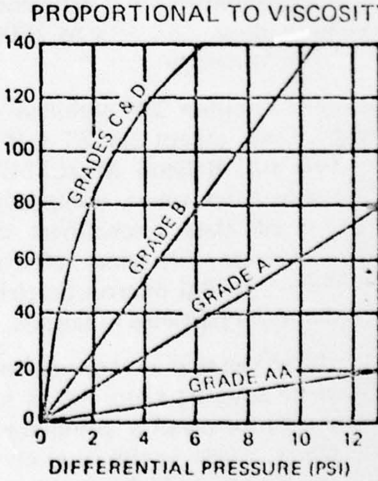
A-0635 HOUSINGS



A-0680 HOUSINGS

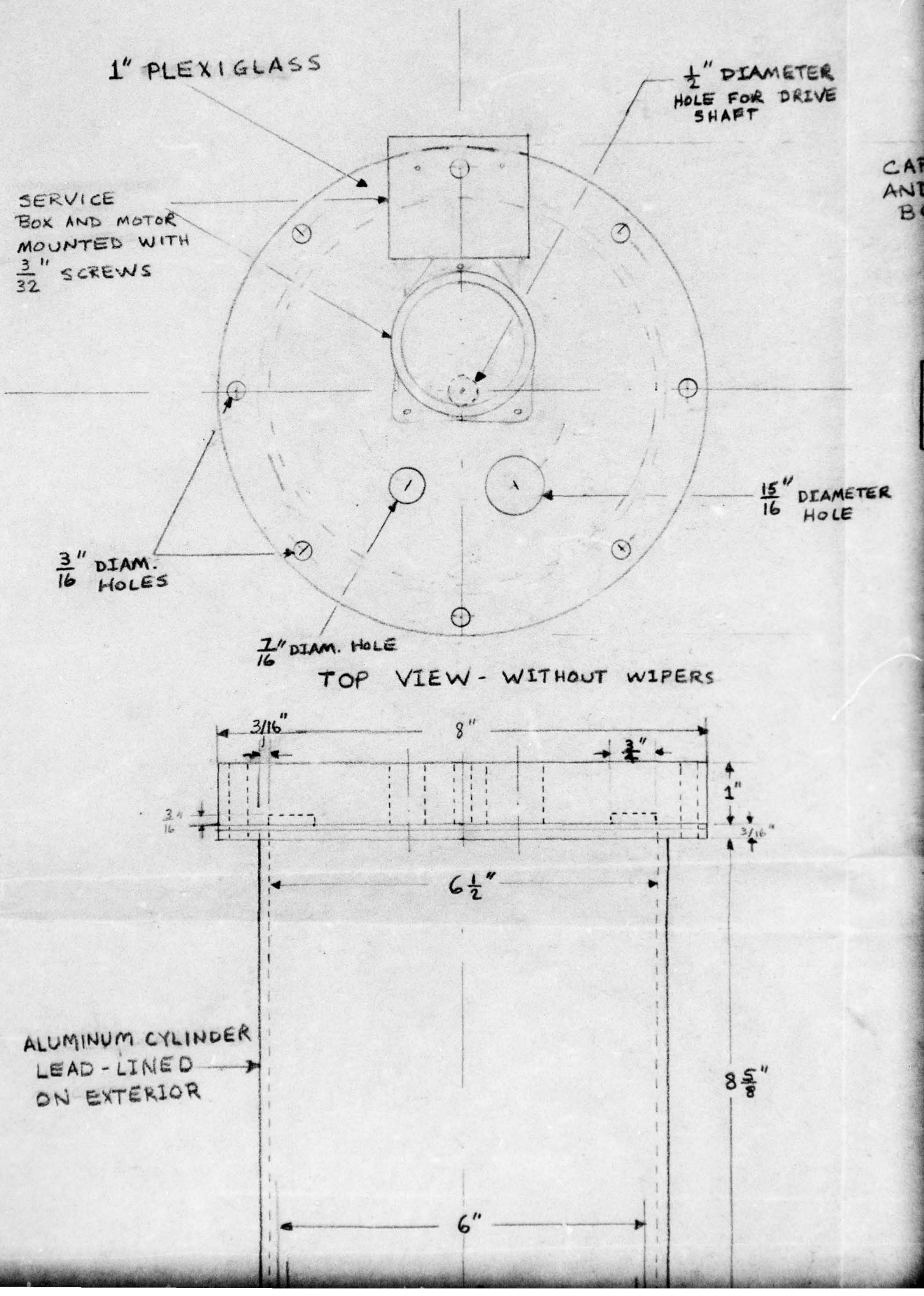


WATER FLOW – A-0680 HOUSINGS*
NOTE: FLOW RATE IS INVERSELY PROPORTIONAL TO VISCOSITY

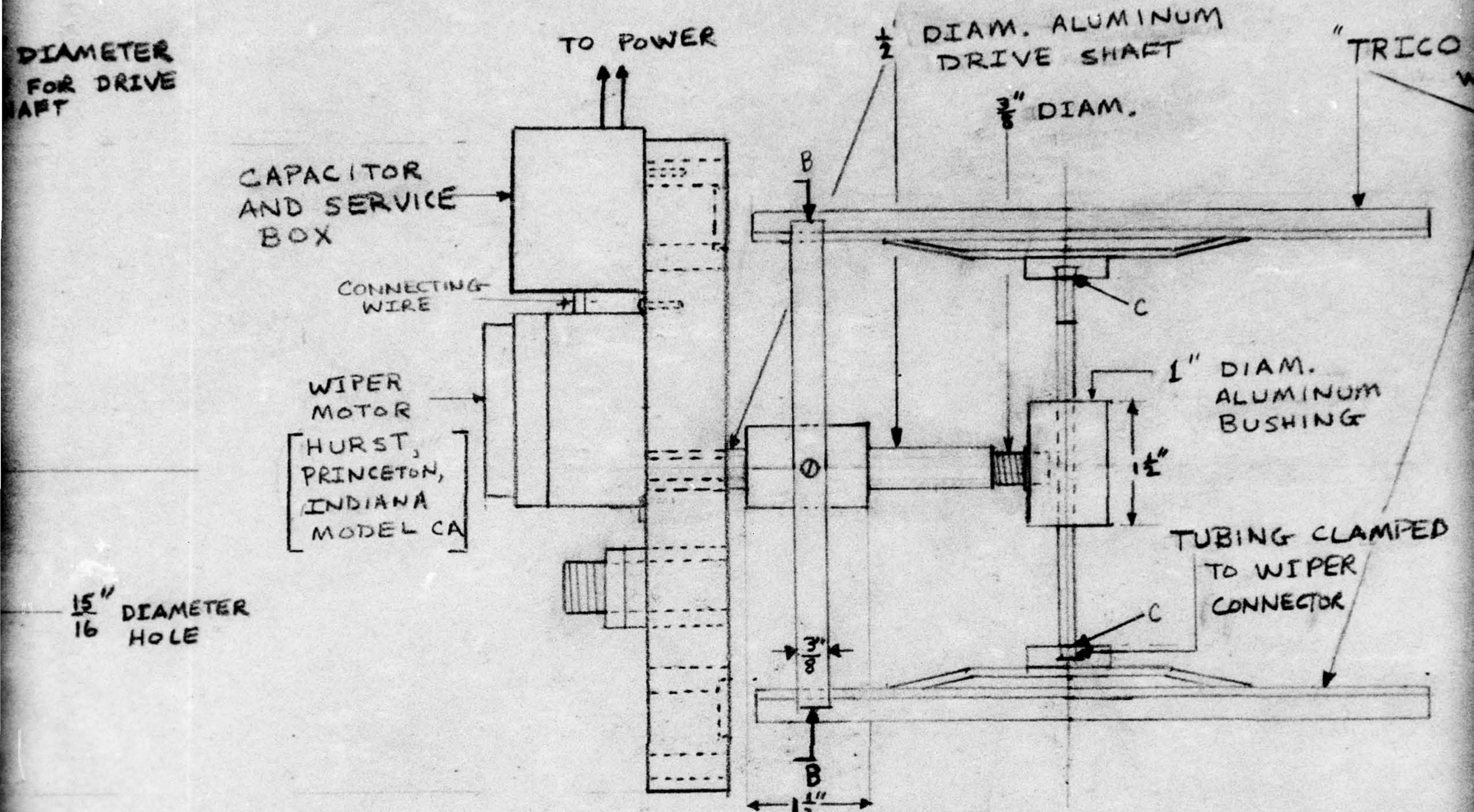


*DIVIDE BY 2 FOR FLOW RATES FOR A 0635 HOUSINGS

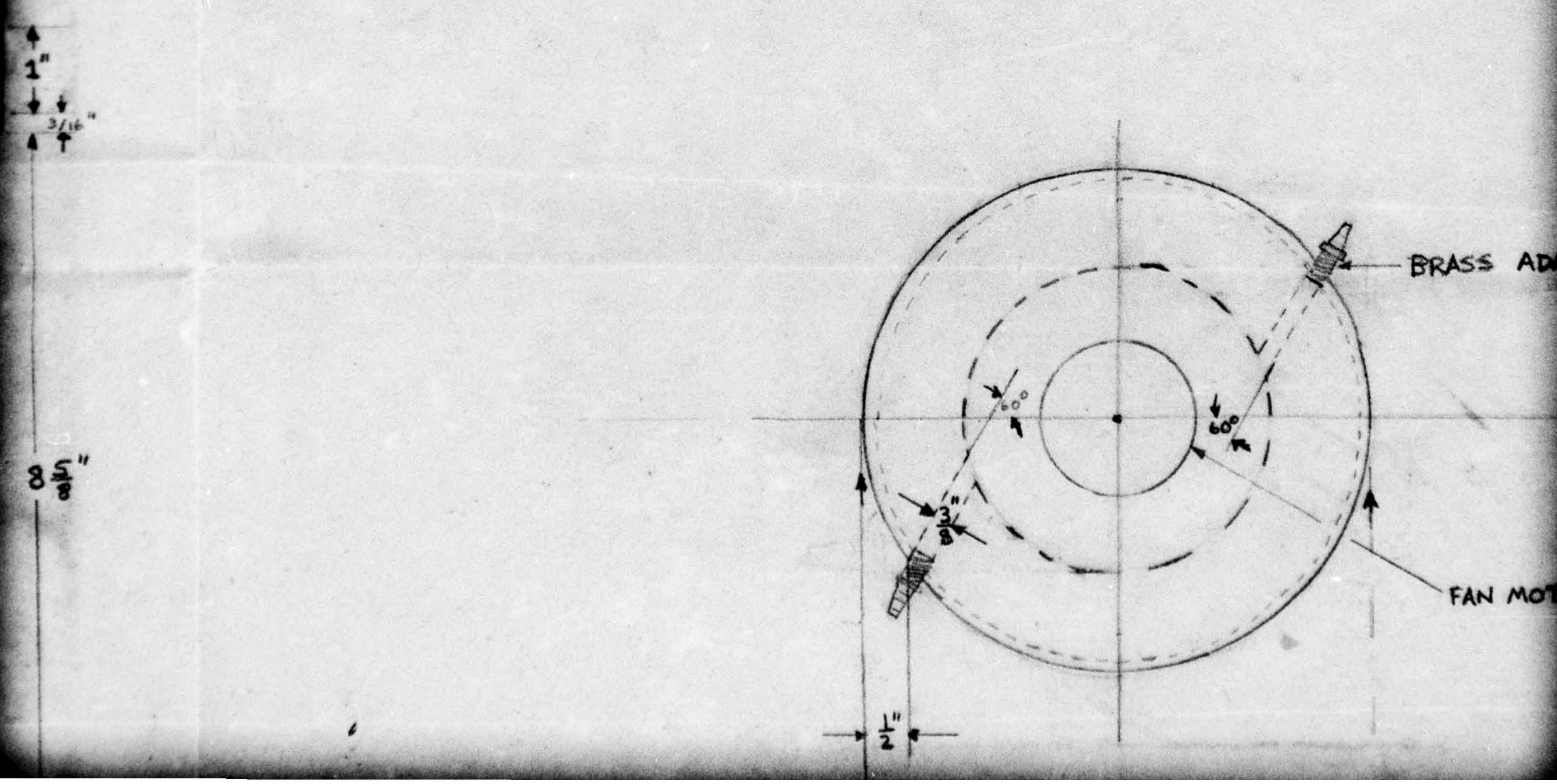
BALSTON, INC.
P.O. Box C, 703 Massachusetts Ave.
Lexington, Massachusetts 02173
(617) 861-7240 · (617) 862-7455
Telex 92-3461

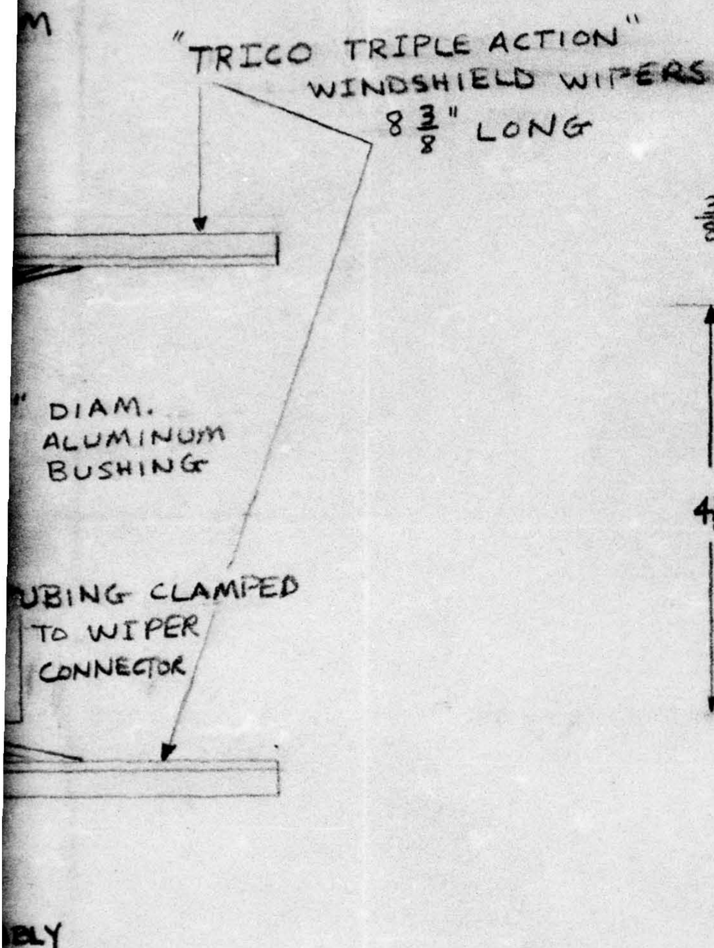

1" PLEXIGLASS
$\frac{1}{2}$" DIAMETER HOLE FOR DRIVE SHAFT
SERVICE BOX AND MOTOR MOUNTED WITH $\frac{3}{32}$" SCREWS
CAP
AND
BO
$\frac{15}{16}$" DIAMETER HOLE
$\frac{3}{16}$" DIAM. HOLES
$\frac{7}{16}$" DIAM. HOLE
TOP VIEW - WITHOUT WIPERS
3/16"
8"
$\frac{3}{4}$"
1"
$\frac{3}{16}$"
3/16"
$6\frac{1}{2}$"
ALUMINUM CYLINDER LEAD-LINED ON EXTERIOR
$8\frac{5}{8}$"
6"

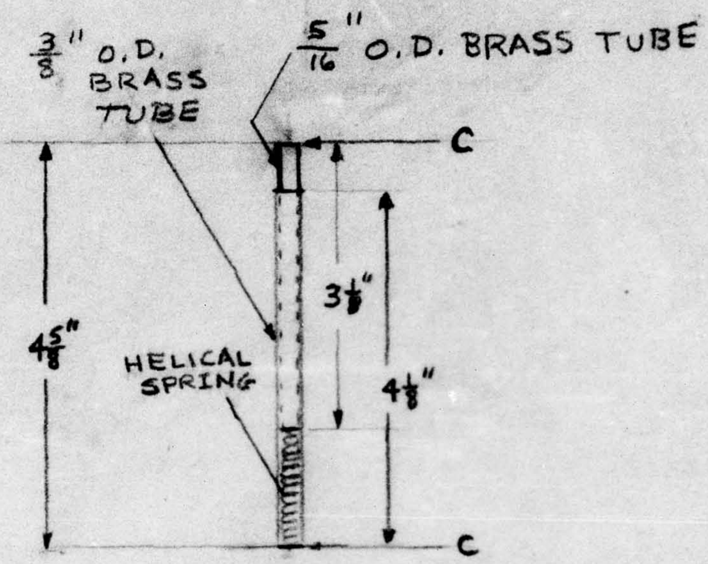
2



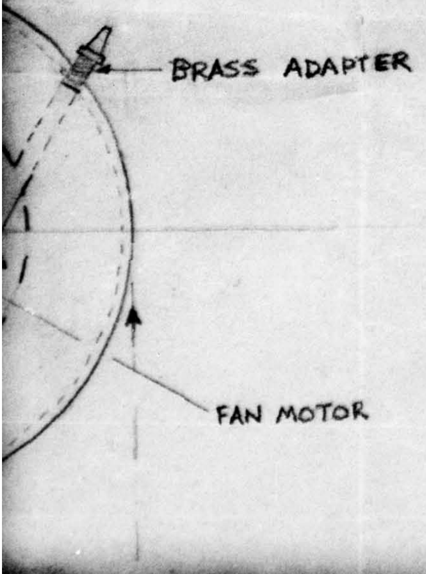
SIDE VIEW - WIPER ASSEMBLY

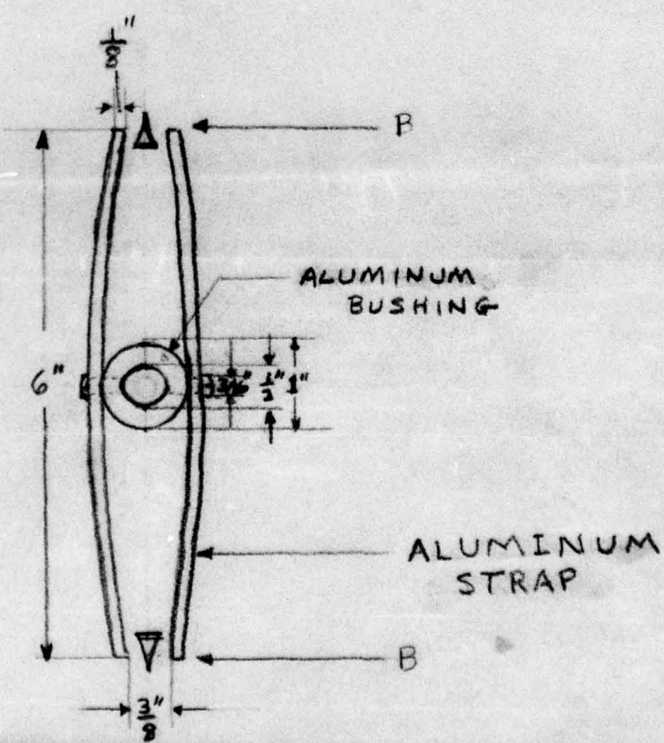






SECTION C - C
WIPER SPRING SUPPORT





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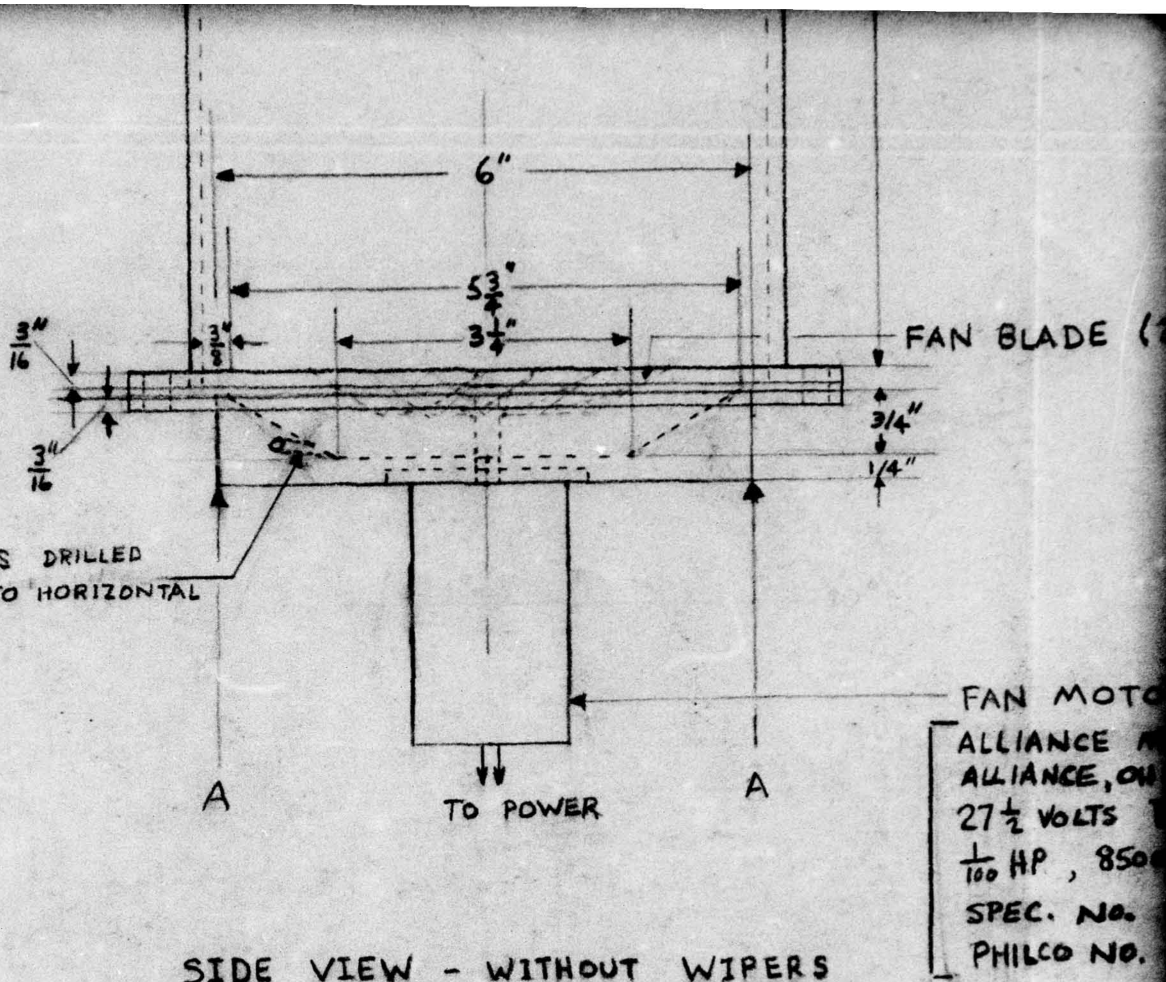
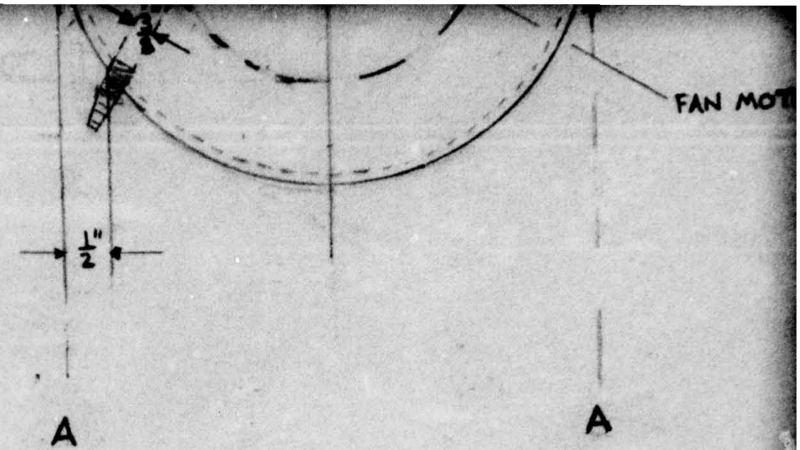


SIDE VIEW - WITHOUT WIPERS

5



SECTION A-A
FAN INLETS
BOTTOM VIEW

FAN BLADE (3 1/2" DIAM.)

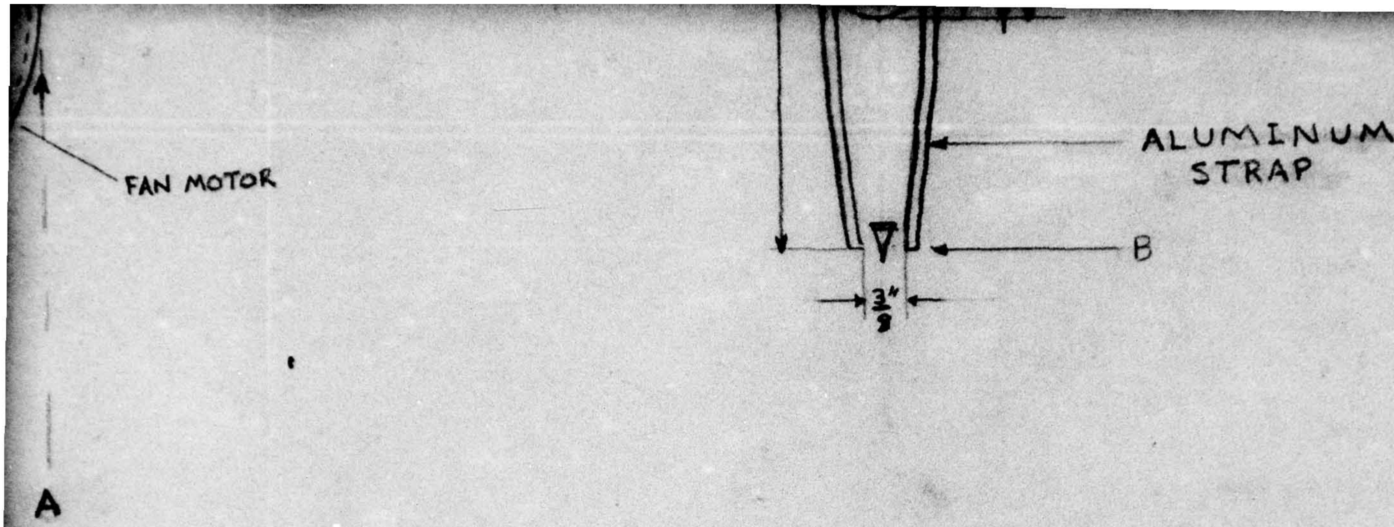
3/4"

1/4"

FAN MOTOR

ALLIANCE MFG.
ALLIANCE, OHIO
27 1/2 VOLTS D.C.
1/100 HP, 8500 RPM
SPEC. No. 2208
PHILCO NO. 451-1157

6

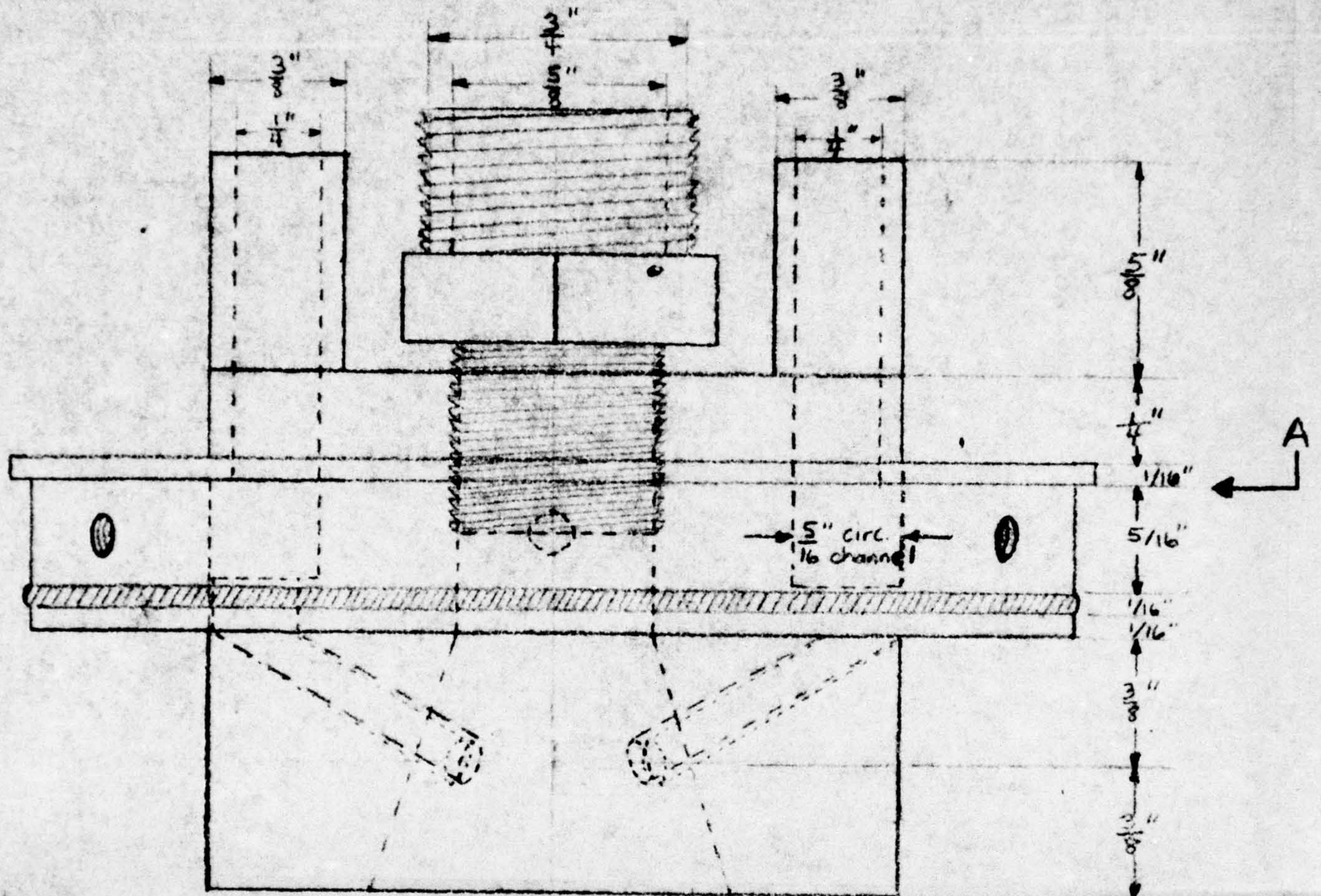


SECTION B-B
WIPER BRACES
TOP VIEW

KETTERING LABORATORY	
SCALE: 1" = 2"	FLUIDIZING GENERATOR
DRAWN BY T L TEAGUE 11-26-75	

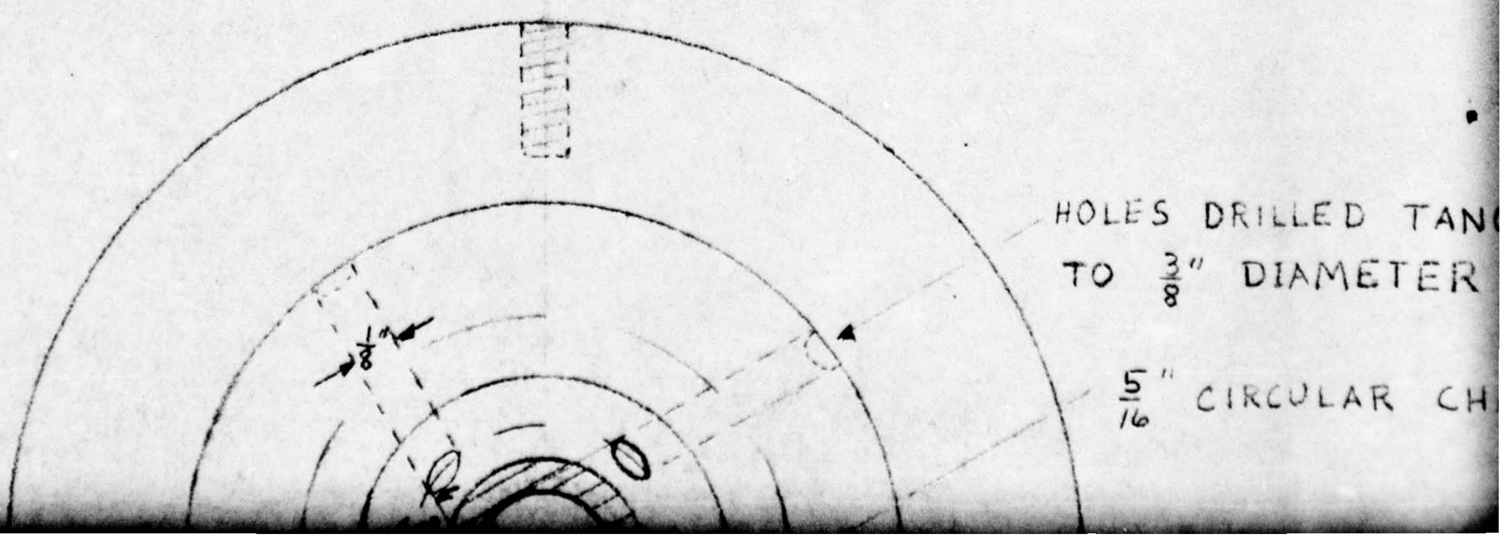
APPENDIX - I - D
Page 54

MIXING HEAD

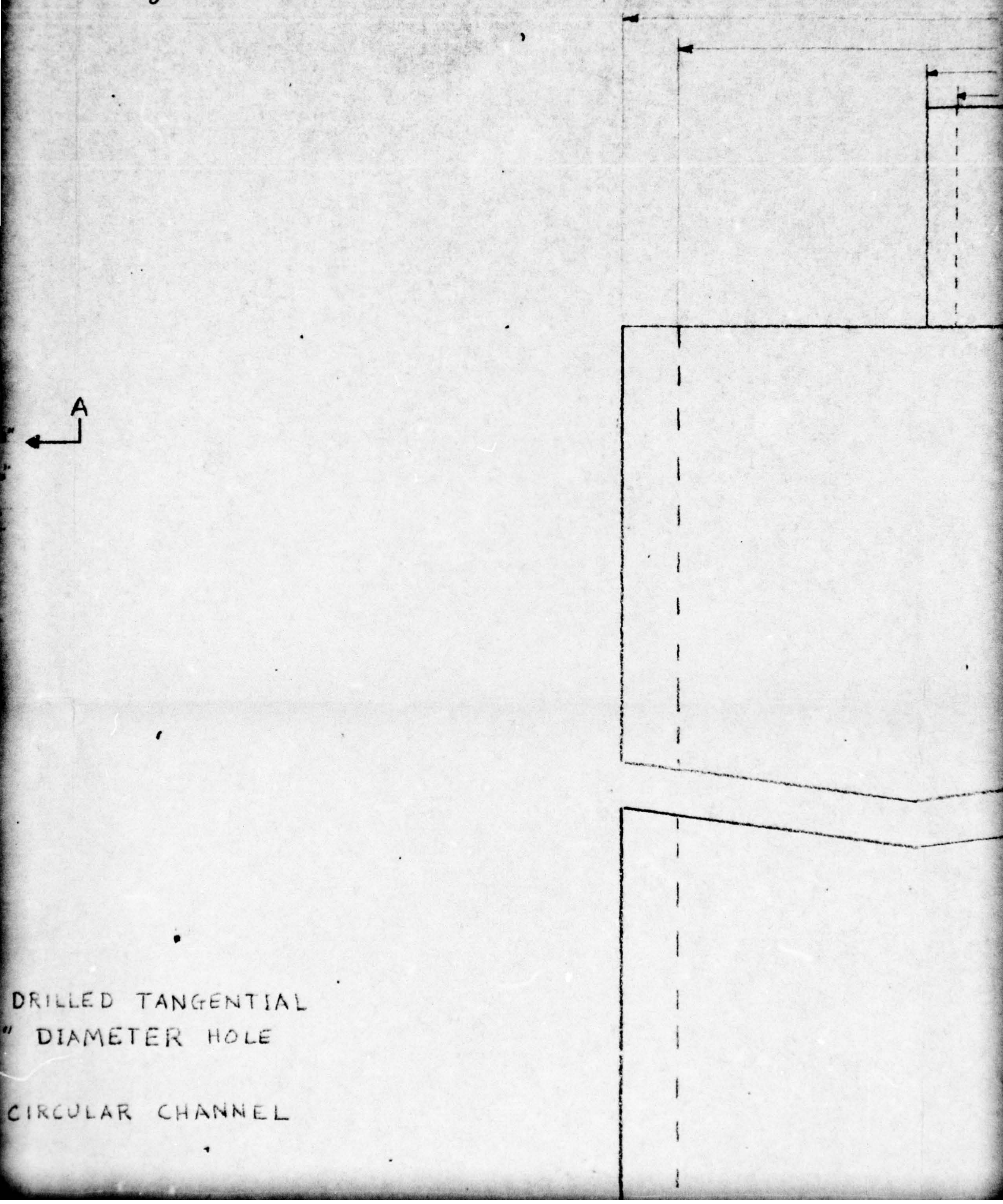


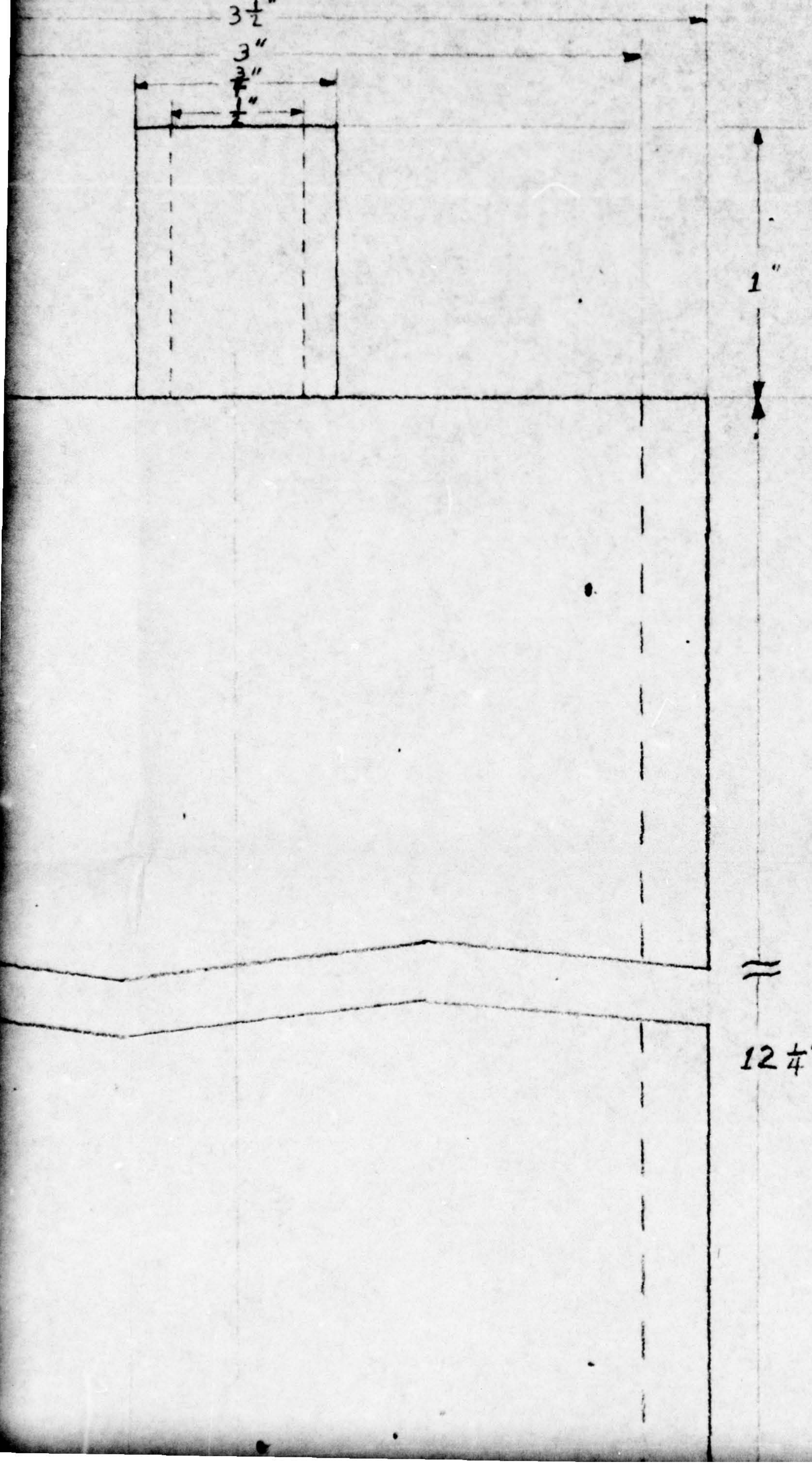
SIDE VIEW

BOTTOM VIEW

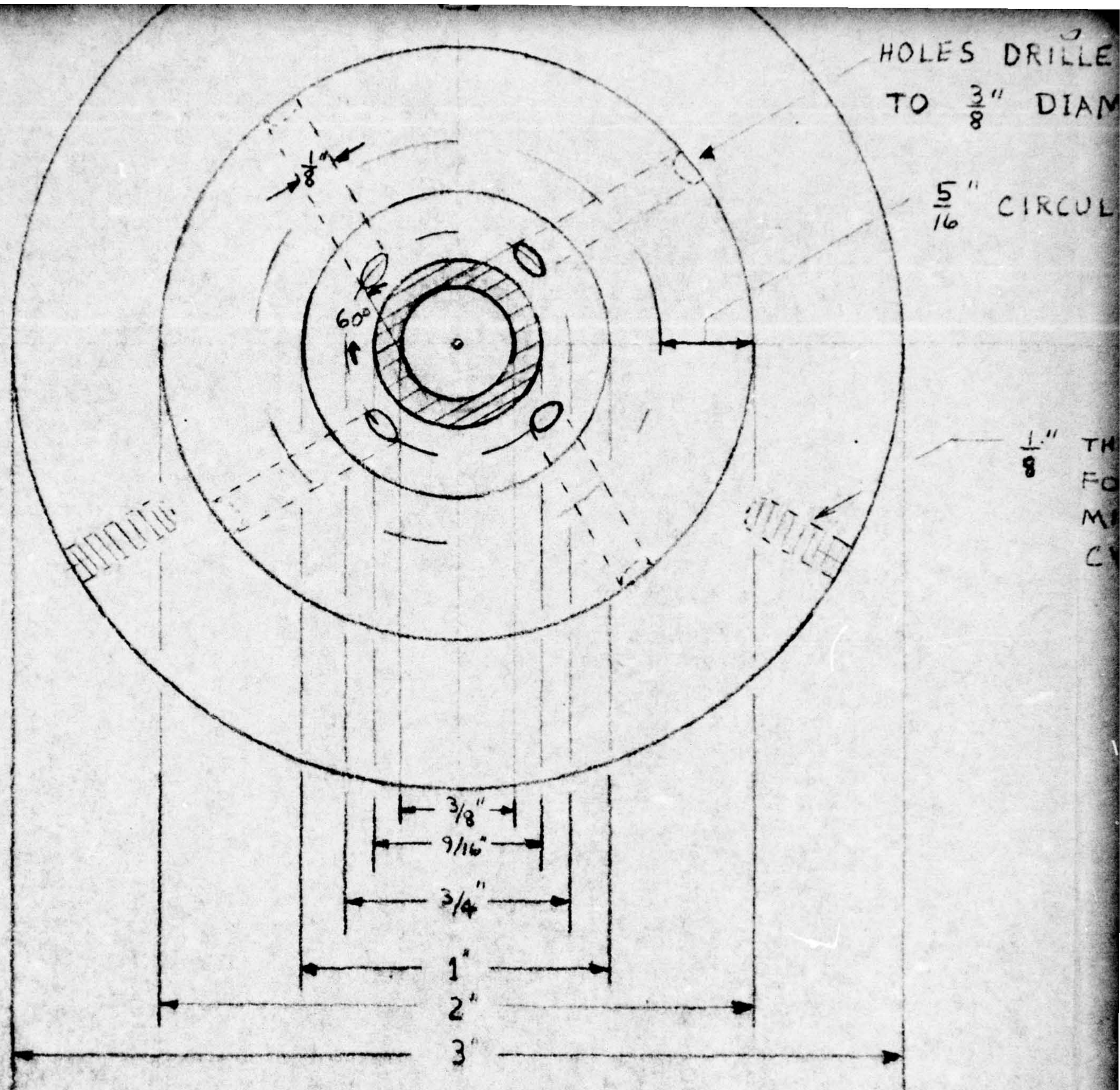


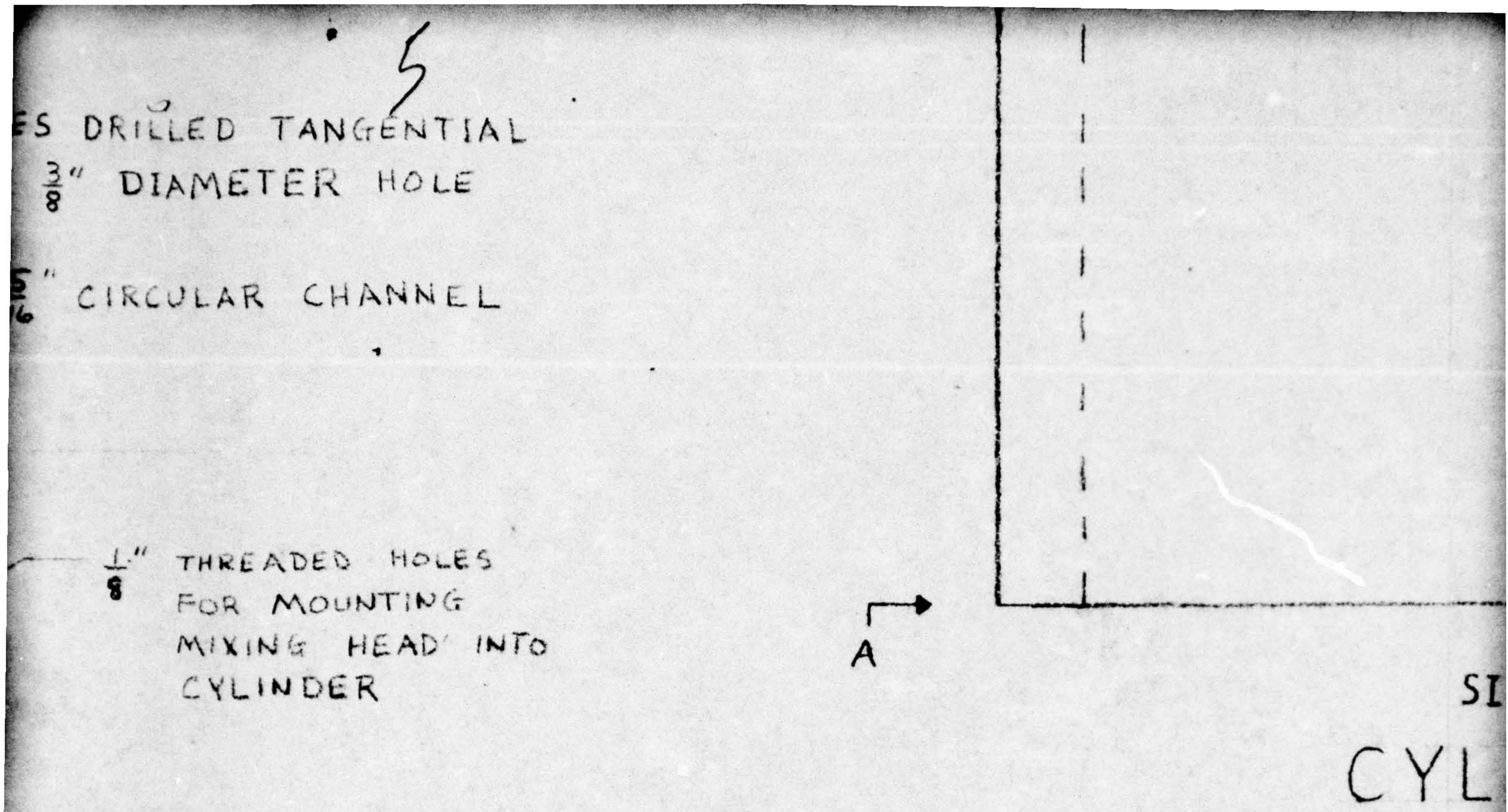
2




3 1/2"
3"
3/4"
1/2"
1"
12 1/4"

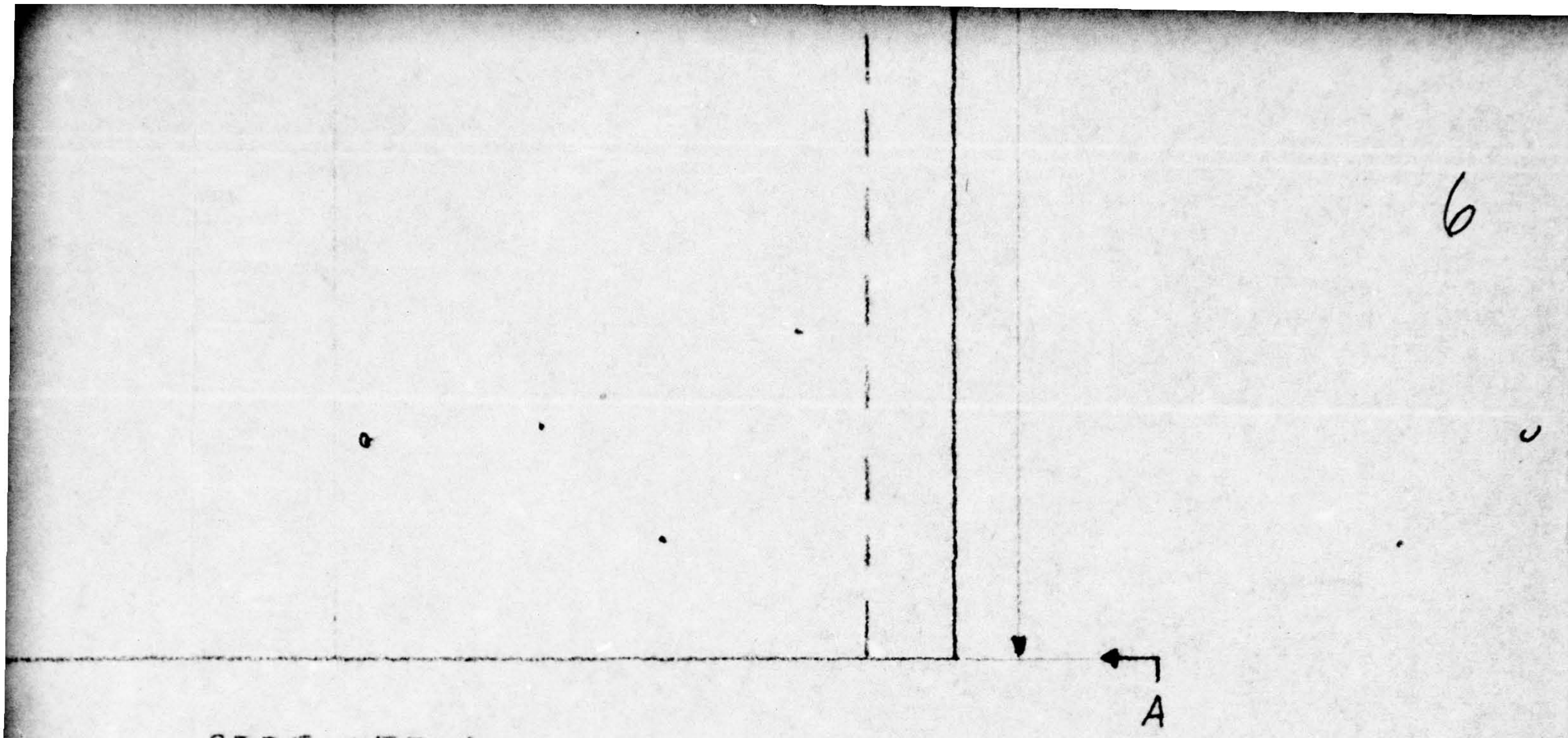
4





ASSEMBLY: INSERT HEAD, CONE SIDE UP, INTO CYLINDER SO THAT A-A ON EACH MEET. MOUNT WITH SCREWS.

6



SIDE VIEW
CYLINDER

KETTERING LABORATORY	
SCALE: 2" = 1"	MIXING HEAD AND CYLINDER
DRAWN BY: T L TEAGUE 4-8-76	

Side-channel compressors
Compresseurs annulaires
Compresores anulares
Soffiante ad anello
Högtrycksfläkt

Betriebsanleitung

EWN 610.40859/21

APPENDIX I-F Page 56

Verwendung

Die Ringverdichter sind geeignet zur Förderung von Luft und anderen nicht brennbaren, nicht aggressiven und nicht explosiven Gasen. Durch Festkörper verunreinigte Gase dürfen nicht gefördert werden. Die Ringverdichter sind für Dauerbetrieb geeignet und praktisch wartungsfrei.

Aufstellung

Die Ringverdichter können beliebig aufgestellt werden. Ringverdichter- und Motorkühlung nicht behindern!

Geräusche

Zur Minderung der Geräuschabstrahlung Ringverdichter nicht an schalleitende oder schallabstrahlende Teile (z. B. dünne Wände, Blechplatten o. ä.) anbauen. Evtl. schalldämmende Zwischenlage vorsehen. Bei freiem Ansaugen oder Ausblasen kann das Geräusch durch Anbau eines Zusatz-Schalldämpfers gemindert werden (siehe Katalog P 2).

Druckschwankungen und Temperaturen

Typ	maximal zulässige Umgebungstemperatur	zul. Fördermitteltemperatur am Ringverdichtereintritt mit 3~ Motoren	mit Sondermotoren (Ex)e-CSA-Einphasen-	Bei folgenden Fördermengen arbeiten die Ringverdichter in einem instabilen Bereich, d. h. es können Druckschwankungen auftreten
2CH2				< 0,6 m³/min
2CH3				< 0,3 m³/min
2CH4	40 °C	75 °C	40 °C	< 0,9 m³/min
2CH5				< 1,1 m³/min
2CH51				< 1,6 m³/min
2CH6				< 1,5 m³/min

Beim Durchgang durch den Ringverdichter wird das Fördermittel erwärmt.

Förderrichtung und Klemmenkasten

◄—: Förderrichtung

Drehrichtung an der Stirnseite durch Pfeil gekennzeichnet. Umkehrung der Drehrichtung und damit Förderrichtung durch Vertauschen zweier Außenleitungen. Der erreichte Druck beträgt dann nur noch 40 % des vorherigen bei gleicher Fördermenge.

◄—: Direction of flow

Direction of rotation on discharge side marked by an arrow. Reversal of direction (of rotation and of flow) by interchanging two main leads. Pressure attained then is only 40 % of previous pressure at same delivery rate.

Application

The compressors are suitable for handling air and other non-flammable, non-aggressive and non-explosive gases. Gases contanimated by solid bodies must not be handled. The compressors are designed for continuous operation and require no maintenance.

Installation

The compressor can be installed in any position desired. Cooling of the compressor and motor must not be impeded.

Noise

To minimize noise, do not mount the compressor on sound conducting or sound emitting parts (e.g. thin walls, metal panels etc.). If necessary fit sound suppressing mounting pad. With a free intape or discharge noise can be minimized by fitting an additional silencer (see Catalogue P 2).

Fluctuations in pressure and temperature

Type	Max permissible ambient temp.	Permissible temp. of medium handled at compressor intake with 3-ph. motors	with special motors 1-ph. (Ex)e - CSA	The compressors operate in an unstable range at the following delivery rates, i.e. fluctuations in pressure may arise
2CH2				< 0,6 m³/min
2CH3				< 0,3 m³/min
2CH4	40 °C	75 °C	40 °C	< 0,9 m³/min
2CH5				< 1,1 m³/min
2CH51				< 1,6 m³/min
2CH6				< 1,5 m³/min

The medium handled is heated while passing through the compressor.

Direction of flow and terminal box

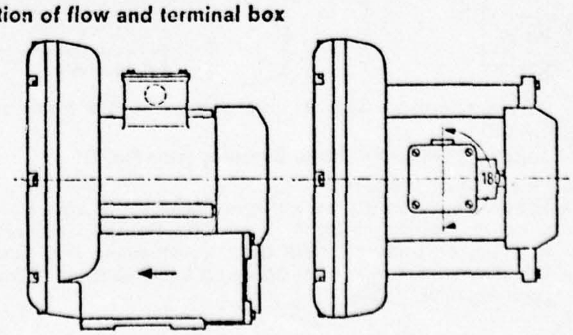


Fig. 1

Vorsicht! Alle Arbeiten nur im spannungslosen Zustand der Maschine vornehmen!
Netzspannung und Netzfrequenz müssen mit den Daten auf dem Leistungsschild übereinstimmen. ±5 % Spannungs- oder Frequenzabweichungen sind ohne Leistungsherabsetzung zulässig. Wenn im Einzelfalle zeitweise höhere Spannungen auftreten, empfiehlt es sich, den Motorschutzschalter für einen Strom, der etwa 10 % über dem Nennstrom liegt, einzustellen. Anschluß und Anordnung der Schaltbügel nach dem im Klemmenkasten befindlichen Schaltbild vornehmen. Schutzleiter an diese Klemme ⏚ anschließen.

(Ex)e-Ringverdichter

Einsatz dieser Ringverdichter nur in Räumen zugelassen, in denen gelegentlich explosive Gase auftreten. Explosive Gase dürfen nicht gefördert werden.
Die auf dem Prüfschild angegebene Zündgruppe ist zu beachten. Jedem Motor muß ein Motorschutzschalter vorgeschaltet sein, der auf den Motornennstrom einzustellen ist und im Kurzschlußfall (bei festgebremstem Läufer) innerhalb der zulässigen t_E-Zeit auslöst.
Reparaturen müssen in Siemens-Werkstätten durchgeführt oder von einem amtlich anerkannten Sachverständigen abgenommen werden.

Auswechseln der Lager

Nach etwa 10000 Betriebsstunden Lager auswechseln (unter normalen Betriebsbedingungen, Umgebungstemperatur etwa 25 °C, stabiler Kennlinienbereich). Erstschmierung mit Aeroshell Grease 16.

Important: Before starting any work on the machine, isolate it from the supply.
Check to see that system voltage and frequency agree with the rating-plate data. Voltage or frequency deviations of ±5 % from the rated values are permitted without the need of derating the output. Should higher voltages occur temporarily, it is recommended that the protective circuit breaker be set for a current which exceeds the rated value by about 10 %. Connection and arrangement of the terminal links have to agree with the diagram shown in the terminal box. Connect the earthing conductor to the terminal with the ⏚ marking.

(Ex)e-Compressors

The use of these compressors is permitted only in areas in which explosive gases occur occasionally. Explosive gases must not be conveyed.
Note the ignition-temperature group which is given on the rating plate. Each motor shall be provided with a circuit breaker which shall be adjusted to the rated current of the motor. If a short circuit occurs (when the rotor is locked), the breaker shall open the motor circuit within the permissible t_E-time (within the max. permissible temperature is attained in the case of a short circuit or under locked-rotor conditions).

Repairs shall be carried out in a Siemens workshop, otherwise the completed repair must be accepted by an authorized inspector.

Replacing the bearings

Replace the bearings after about 10,000 operating hours. (For normal service conditions, ambient temperature about 25 °C, stable range of characteristic.) Pack bearings with Aeroshell Grease 16.

Utilisation

Les compresseurs sont conçues pour le transport de l'air ou d'autres gaz non corrosifs et non explosibles. Des gaz poulés par des corps solides ne doivent pas être transportés. Les compresseurs sont conçues pour un service continu et n'exigent aucun entretien.

Installation

Les compresseurs peuvent étre installées dans n'importe quelle position. Ne pas gêner le refroidissement du compresseur et du moteur.

Bruits

Pour diminuer le bruit, éviter de monter les compresseurs sur des parois conductrices ou diffusant le son (p.ex. parois de faible épaisseur, tôles, etc.). Le cas échéant, monter des pièces intercalaires insonorisantes. En cas d'aspiration ou de refoulement libre, une diminution du bruit peut être obtenue en montant un silencieux supplémentaire (voir catalogue P 2).

Variations de pression et températures

Type	Température ambiante max. admissible	Temperature adm. du gaz à l'entrée du compresseur: Moteurs triphasés	Moteurs spéciaux (Ex)e CSA monophasés	Dans le cas des débits suivants, les compresseurs fonctionnent dans un régime instable, c'est-à-dire que des variations de pression peuvent se présenter
2CH2				< 0,6 m³/min
2CH3				< 0,3 m³/min
2CH4	40 °C	75 °C	40 °C	< 0,9 m³/min
2CH5				< 1,1 m³/min
2CH51				< 1,6 m³/min
2CH6				< 1,5 m³/min

Lors du passage dans le compresseur le gaz transporté est échauffé.

Sens de transport et boîte à bornes (voir Fig. 1)

←: Sens de transport
Sens de rotation repéré par une flèche sur le côté frontal. Le sens de rotation et donc le sens de transport peuvent être inversés en intervertissant deux conducteurs d'alimentation. La pression obtenue n'est égale qu'au 40 % de la précédente pour le même débit.

Empleo

Los compresores anulares pueden instalarse en la posición aire y otros gases incombustibles, inexplosivos y no agresivos. Se excluyen los gases ensuciados por la presencia de cuerpos sólidos. Los compresores anulares pueden prestar servicio permanente, y no están sujetos a trabajos de mantenimiento.

Colocación

Los compresores anulares pueden instalarse en la posición que se desee. Se evitará que se vea impedida la refrigeración del motor y del compresor.

Ruidos

Para reducir la propagación de ruidos, no montar los compresores sobre partes que propaguen o irradien el sonido (por ejemplo, paredes delgadas, placas de chapa, etc.). Si fuese preciso, prever suplementos insonorizantes. En caso de aspiración o expulsión libre, puede disminuirse el ruido montando un amortiguador de sonido adicional (véase catálogo P 2).

Fluctuaciones de la presión y temperaturas

Tipo	Temperatura ambiente máx. admisible	Temperatura admisible del medio impulsado a la entrada del compresor: Motores trifásicos	Motores especiales (Ex)e - CSA monofásicos	Cuando los caudales impulsados son los indicados a continuación, los compresores trabajan en una zona inestable, es decir, pueden tener lugar fluctuaciones de presión
2CH2				< 0,6 m³/min
2CH3				< 0,3 m³/min
2CH4	40 °C	75 °C	40 °C	< 0,9 m³/min
2CH5				< 1,1 m³/min
2CH51				< 1,6 m³/min
2CH6				< 1,5 m³/min

El medio impulsado se calienta al pasar por el compresor.

Dirección de impulsión y caja bornas (véase Fig. 1)

←: Dirección de impulsión
El sentido de giro se ha marcado con una flecha en la parte frontal. Intercambiando dos conductores de empalme puede invertirse el sentido de giro, y, por tanto la dirección de impulsión. En tal caso, con la misma cantidad impulsada, la presión conseguida es solamente 40 % de la precedente.

1.00 Lagerung AS
.30 Lagerdeckel außen
.60 Wälzlager
.75 Radialdichtung
.80 Lagerdeckel innen

2.00 Ringverdichter-Teile
.40 Gehäuse
.53 Deckel
.60 Laufrad
.62 Schalldämpfer
.63 Abdeckung

3.00 Läufer komplett

4.00 Motorgehäuse komplett

5.00 Klemmenkasten komplett

6.00 Lagerung BS
.08 Nilosring
.10 Wälzlager
.16 Federscheiben
.20 Lagerschild

7.00 Belüftung des Motors
.04 Außenlüfter
.40 Lüfterhaube

* Ersatzteile vom Werk lieferbar!

1.00 Bearing assembly, drive end
.30 Outer bearing cap
.60 Rolling-contact bearing
.75 Radial seal
.80 Inner bearing cap

2.00 Compressor components
.40 Housing
.53 Cap
.60 Impeller
.62 Silencer
.63 Cap

3.00 Rotor, complete

4.00 Motor frame, complete

5.00 Terminal box, complete

6.00 Bearing assembly, non drive end
.08 Sealing ring
.10 Rolling-contact bearing
.16 Resilient preloading rings
.20 End shield

7.00 Ventilating accessories for the motor
.04 External fan
.40 Fan cowl

* Spare parts to be ordered from our works.

1.00 Logement côté entraînement
.30 Chapeau de palier extérieur
.60 Roulement
.75 Joint radial
.80 Chapeau de palier intérieur

2.00 Pièces du compresseur
.40 Carcasse
.53 Couvercle
.60 Roue de ventilation
.62 Silencieux
.63 Obturateur

3.00 Rotor, complet

4.00 Carcasse du moteur, complète

5.00 Boîtes à bornes, complète

6.00 Logement côté opposé à l'entraînement
.08 Bague
.10 Roulement
.16 Rondelle élastique
.20 Flasque – palier

7.00 Ventilation du moteur
.04 Ventilateur extérieur
.40 Capot du ventilateur

* Peut être fourni par l'usine comme pièce de rechange.

* Beispiel:
Example:
Exemple:
Ejemplo:
Esempiô:
Exempel:

2CH4 002 E 167456887001 Laufrad 2.60

Norm-Teile sind nach Muster im freien Handel zu beziehen.

The standard parts can be procured according to samples from local dealers.

On se procurera dans le commerce les pièces normalisées en vue d'un échantillon.

Las piezas normalizadas, según muestro, pueden adquirirse en el comercio.

Le parti sono normalizatte e reperibili secondo campione in commercio.

Normerad del kan erhållas i fria handeln enl mönster.

Anzugsmoment für Teil 2.55

Tightening torque for part 2.55

Couple de serrage pour pièce 2.55

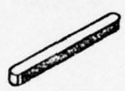
Par de apriete para la pieza 2.55

Coppia di spunto per la parte 2.55

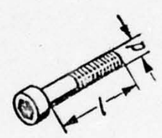
Atdragningsmoment för del 2.55

2CH2	2CH3	2CH4	2CH5	2CH6	
4	6	6	6	12	mkp mkgf

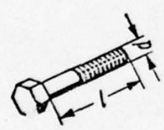
3.38 DIN 6885



1.34 DIN 6912



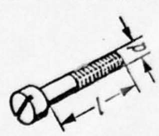
1.26
2.21
6.64
7.45
DIN 933



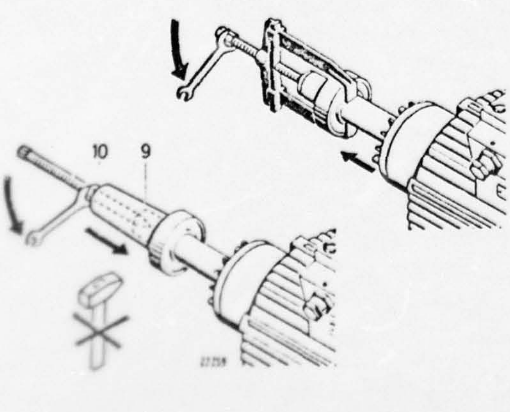
2.56 DIN 127

1.36 DIN 125

2.51 DIN 84



2.55 DIN 934



9 Treibhülse
10 Spindel

9 Driving sleeve
10 Spindle

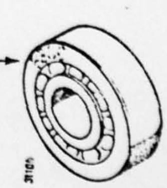
9 Douille d'emmanchement
10 Tige

9 Casquilla de empuje
10 Husillo

9 Campana di spinta
10 Perno filettato

9 Drivhylsa
10 Spindel

Lagertyp:
Type of bearing:
Type de roulement:
Tipo de cojinete:
Tipo di cuscinetto:
Lagertyp:



DIN 625

Piezas de recambio*

1.00 Cojinete del lado de accionamiento
.30 Tapa exterior del cojinete
.60 Cojinete de rodamiento
.75 Junta radial
.80 Tapa interior del cojinete

2.00 Partes del compresor
.40 Carcasa
.53 Tapa
.60 Rodete
.62 Amortiguador de sonido
.63 Tapa

3.00 Rotor, completo

4.00 Carcasa del motor, completa

5.00 Caja de bornes, completa

6.00 Cojinete del lado de servicio
.08 Anillo Nilos
.10 Cojinete de rodamiento
.16 Arandela elástica
.20 Escudo portacojinetes

7.00 Ventilación del motor
.04 Ventilador exterior
.40 Tapa del ventilador

* Se suministra por la fábrica en calidad de pieza de repuesto

Pezzi di riserva*

1.00 Supporto lato comando
.30 Coperchio del cuscinetto esterno
.60 Cuscinetto di rotolamento
.75 Guarnizione radiale
.80 Coperchio del cuscinetto interno

2.00 Rotore del ventilatore
.40 Carcassa
.53 Coperchio
.60 Girante
.62 Smorzatore rumori
.63 Copertura

3.00 Rotore completo

4.00 Carcassa del motore completa

5.00 Scatola morsetti completa

6.00 Supporto opposto al lato comando
.08 Anello Nilos
.10 Cuscinetto di rotolamento
.16 Anello elastico
.20 Scudo di supporto

7.00 Ventilazione del motore
.04 Ventole esterne
.40 Cappa della ventola

* Viene fornito come pezzo di ricambio della fabbrica.

Reservdelar*

1.00 Lageranordning axeltappsidan
.30 Yttre lagerlock
.60 Rullager
.75 Radialtätning
.80 Inre lagerlock

2.00 Fläktdelar
.40 Kåpa
.53 Lock
.60 Vinghiul
.62 Ljuddämpare
.63 Anslutningsfläns

3.00 Rotor, komplett

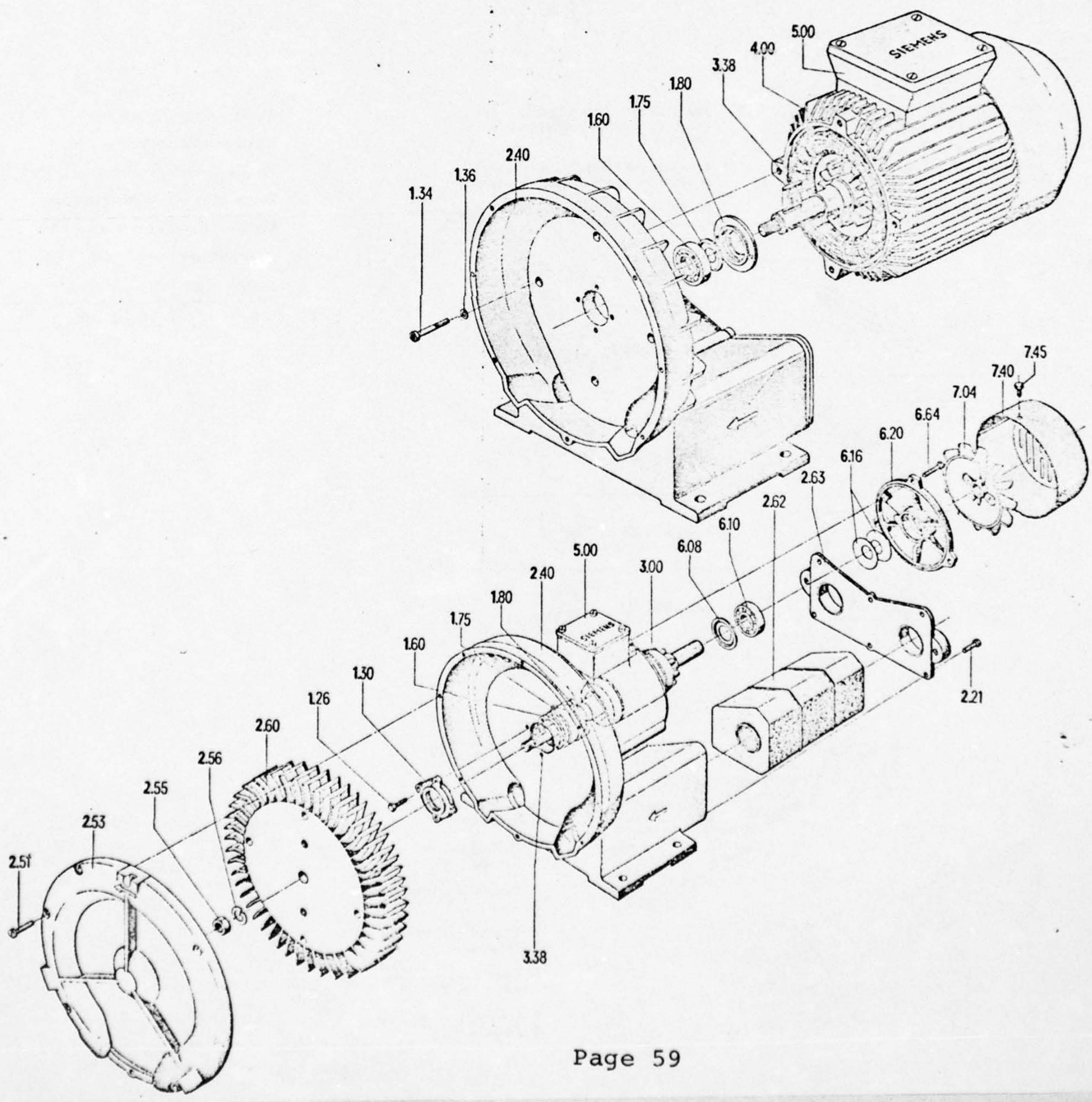
4.00 Motorhölje, komplett

5.00 Anslutningslåda, komplett

6.00 Lageranordning fläktsidan
.08 Tätning från f:a Nilos
.10 Rullager
.16 Fjäderbrickor
.20 Lagersköld

7.00 Motors kylning
.04 Fläkt
.40 Fläktkåpa

* Kan beställas som reservdel från fabriken.



Raccordement

Attention! Lors de tous travaux sur la machine, il faut veiller à ce qu'elle soit hors tension.
Comparer la tension et la fréquence du réseau aux indications de la plaque signalétique. Une variation de ± 5 % de la tension ou de la fréquence est admissible sans abaissement de la puissance. Si, dans certains cas des tensions supérieures se présentent temporairement il est recommandé de régler le disjoncteur série moteurs pour une intensité supérieure d'environ 10 % à l'intensité nominale. Réaliser le branchement et la disposition des barrettes de couplage conformément au schéma suité dans la boite à bornes. Raccorder le conducteur de protection à cette borne ⏚.

(Ex)e Compresseurs

L'emploi de cette compresseur n'est autorise que dans des locaux dans lequels, les gaz explosifs ne se présentent qu'occasion nellement. Les gaz explosifs ne doivent pas être propulsés par la soufflante.
Observer le groupe d'inflammation indiqué sur la plaque signalétique. Chaque moteur doit comporter en amount un disjoncteur série moteurs. Ce disjoncteur est à régler sur l'intensité nominale de moteur. En cas de court-circuit (en cas de rotor bloqué), le disjoncteur doit déclencher dans l'intervalle de temps admissible t_E.
Les réparations doivent être effectuées dans des ateliers Siemens ou ótre réceptionnées par un expert offiziellement reconnu.

Echange des roulements

An bout 10000 heures des service environ, remplacer les palier. (Dans de conditions de service normales, température ambiante 25 °C env., plage de régime stable). Premier graissage avec Aeroshell Grease 16.

Conexión

¡Atención! Antes de emprender cualquier trabajo, cerciorarse de que la máquina no está bajo tensión.
La tensión y frecuencia de la red tienen que ser las indicadas en la placa de características. Son admisibles desviaciones de tensión o de frecuencia de hasta ±5 %, sin que por ello disminuya la potencia. Si en casos aislados, y pasajeramente, se presentan tensiones más elevadas, se recomienda ajustar el guardamotor para una intensidad superior en un 10 %, aproximadamente, a la nominal. Llevar a cabo el empalme y la colocación de los estribos de maniobra según el esquema que se encuentra en la caja de bornas. Empalmar el conductor de protección al borne marcado con ⏚.

(Ex)e Compresores

Solamente está permitido instalar estos compresores en locales donde, ocasionalmente, existan gases explosivos. La extracción de dichos gases no está admitida.
Observar el grupo de encendido en la placa de ensayo. A cada motor deberá preconectarse un guardamotor que se ajustará a la intensidad nominal del primero y que en caso de cortocircuito (con el rotor frenado) dispare dentro del tiempo t_E admitido.
Las reparaciones se realizarán en la fábricas de Siemens o bien serán efectuadas por especialistas oficialmente reconocidos.

Recambio de los cojinetes

Después de 10000 horas de servicio, sustituir los cojinetes. (Bajo condiciones de servicio normales, con temperatura ambiente de 25 °C aproximadamente, y si el compresor trabaja en una zona estable.) Primer engrase con Aeroshell Grease 16.

Impiego

Le soffianti vengono utilizzate per convogliare l'aria ed altri gas non imfiammabili, chimicamente non aggressivi e non esplosivi. Non sono adatte a convogliare gas che contengono impurità. Funzionano in servizio permanente e sono esenti da manutenzione.

Installazione

La posizione d'installazione delle soffianti è indifferente purchè non venga ostacolata la ventilazione del motore oppure della soffiante stessa.

Rumorosità

Per evitare la propagazione dei rumori, le soffianti non dovranno venir installate su pareti a buona conduttività o irradiazione acustica (p.e. pareti sottili, piastre di lamiera o simili). Eventualmente si frappongano dei sitti fonoassorbenti. Con aspirazione o scarico da, rispettivamente verso l'esterno, si può realizzare una riduzione della rumorosità applicando uno smorzatore addizionale (vedi Catalogo P 2).

Variazioni della pressione e temperatura

Tipo	Temperatura ambiente max.	Temperatura ammissibile del mezzo convogliato all'entrata della soffiante: Motore trifase	Temperatura ammissibile del mezzo convogliato all'entrata della soffiante: Motori speciali esecuz. (Ex)e-esecuz. CSA-monofasi	Con el seguenti portate le soffianti funzionano in un campo instabile si possono cioè verificare delle variazioni di pressione
2CH2	40 °C	75 °C	40 °C	< 0,6 m³/min
2CH3				< 0,3 m³/min
2CH4				< 0,9 m³/min
2CH5				< 1,1 m³/min
2CH51				< 1,6 m³/min
2CH6				< 1,5 m³/min

Quando il mezzo convogliato passa attraverso la soffiante, esso viene riscaldato.

Direzione di convogliamento e morsettiera (vedi Fig. 1)

←: Direzione di convogliamento
Il senso di rotazione è contrassegnato da una freccia sul lato frontale. Inversione del senso di rotazione e quindi della direzione di convogliamento si ottiene scambiando gli attacchi di due conduttori. La pressione raggiunta sara allora nuovamente 40 % della precedente a parità di portata.

Användning

Fläktarna lämpar sig för transport av luft och andra ej brännbara, ej aggressiva och ej explosiva gaser. Gaser som förorenats genom fasta kroppar får ej transporteras, Fläktarna lämpar sig för kontinuerlig drift och behöver ej skötas.

Uppställning

Fläktarna kan monteras med godtyckligt axelläge, fläkt- och motorkylningen får emellertid ej hindras.

Buller

För att minska bullret bör fläktarna ej monteras på ljudledande eller -reflekterande delar (t. ex. tunna väggar, plåtar och liknande). Vid behov används ljuddämpande mellanlägg. Vid fri sug- eller trycksluts kan en bullerminskning åstadkommas genom påsättning av en extra ljuddämpare (se Kat P 2).

Tryckvariationer och temperaturer

Typ	Max tillåten omgivningstemperatur	Tillåten gastemperatur på intagssidan: med 3~ motorer	Tillåten gastemperatur på intagssidan: med specialmotorer (Ex)e-CSA-enfas-	Vid följande gasmängder arbetar fläktarna i ett instabilt område, d v s tryckvariationer kan uppstå
2CH2	40 °C	75 °C	40 °C	< 0,6 m³/min
2CH3				< 0,3 m³/min
2CH4				< 0,9 m³/min
2CH5				< 1,1 m³/min
2CH51				< 1,6 m³/min
2CH6				< 1,5 m³/min

Vid passagen genom fläkten uppvärms gasen.

Transportriktning och anslutningslåda (se Fig. 1)

←: Transportriktning
Rotationsriktningen ar angiven med phil på frontsida. Omkastning av rotationsriktningen och därigenom transportriktningen erhålls genom att två anslutningsledningar byts ut. Det uppnådda trycket utgör då endast 40 % av det förra vid lika transportmängd.

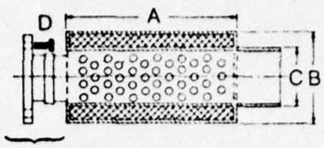
Silencers

Accessories

All Siemens Side Channel Compressors incorporate internal mufflers. However, to reduce noise levels still farther, external silencers are available. These are fabricated of aluminum and are designed so that they may be bent by hand to accommodate mis-alignment between the compressor and connected lines and even can be bent to 90° (see photo) to eliminate an elbow or fit tight quarters. All silencers are supplied straight. They can easily be bent by hand without tools.

Do not fiche

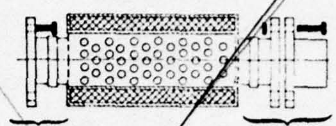
Flanged (F)



See Hose Flange Dimensions

Used where the silencer is mounted on the compressor and discharge is directly to atmosphere, as is the case in some vacuum applications.

Flange to Nipple (F/N)

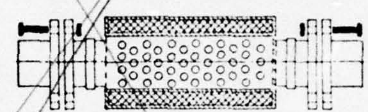


See Hose Flange Dimensions

See Hose Flange Dimensions

Used where the silencer mounts on the compressor and discharge is into a hose.

Nipple to Nipple (N/N)

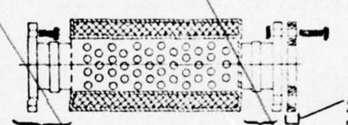


See Hose Flange Dimensions

See Hose Flange Dimensions

Used where the silencer is to be installed in a hose line.

Flange to Pipe (F/P)



See Hose Flange Dimensions

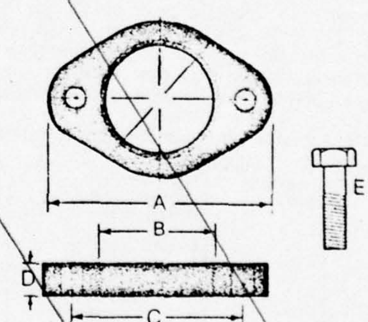
See Hose Flange Dimensions

See Pipe Flange Dimensions

Used where the silencer is to be mounted on the compressor and discharge is into piping. (Terminates in a threaded pipe flange on one end.)

Flanges and Gaskets

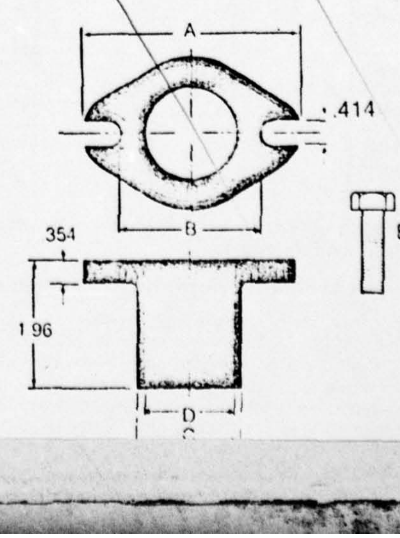
THREADED PIPE FLANGE



Two types of flanges are available, threaded pipe flanges and hose flanges.

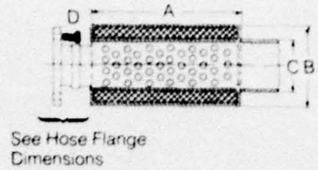
The accompanying drawings and tables give part numbers and significant dimensions.

HOSE FLANGE



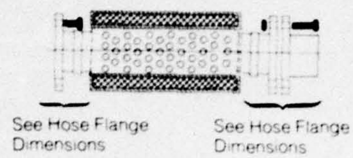
Accessories

All Siemens Side Channel Compressors incorporate internal mufflers. However, to reduce noise levels still farther, external silencers are available. These are fabricated of aluminum and are designed so that they may be bent by hand to accommodate mis-alignment between the compressor and connected lines and even can be bent to 90° (see photo) to eliminate an elbow or fit tight quarters. All silencers are supplied straight. They can easily be bent by hand without tools.



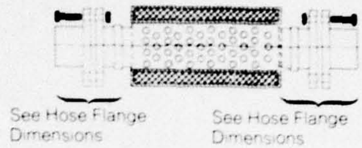
Flanged (F)

Used where the silencer is mounted on the compressor and discharge is directly to atmosphere, as is the case in some vacuum applications.



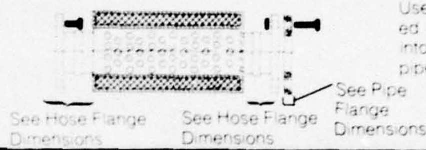
Flange to Nipple (F/N)

Used where the silencer mounts on the compressor and discharge is into a hose.



Nipple to Nipple (N/N)

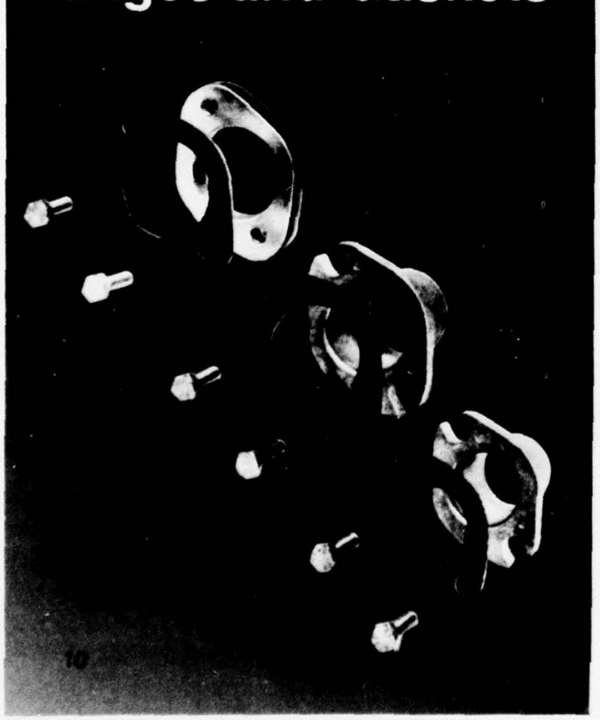
Used where the silencer is to be installed in a hose line.



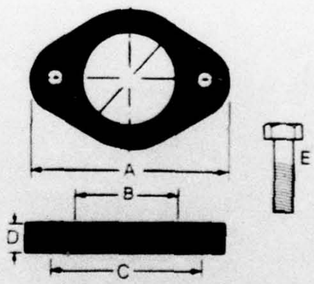
Flange to Pipe (F/P)

Used where the silencer is to be mounted on the compressor and discharge is into piping. (Terminates in a threaded pipe flange on one end.)

Flanges and Gaskets



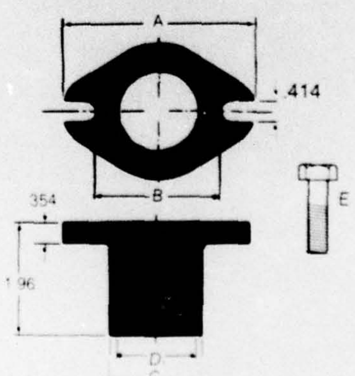
THREADED PIPE FLANGE



Two types of flanges are available: threaded pipe flanges and hose flanges.

The accompanying drawings and tables give part numbers and significant dimensions.

HOSE FLANGE



Attenuation with External Silencer

Compressor Series	Noise Level Without External Silencer*		Reduction With External Silencer*	
	60Hz	50Hz	Overall dB(A)	dB(A) @ 2100Hz
2CH2	74	72	10	20
2CH3	69	66	5	9
2CH4	73	69	4	7
2CH5	77	73	5	8
2CH51	77	73	5	8
2CH6	80	77	6	8

*Measured at a distance of 3 feet and at 50% maximum ΔP

External Silencer Part Nos.

Compressor Series	Flanged*	Flange to Nipple*	Nipple to Nipple	Flange to Pipe
2CH2	2CX1 030-1F	2CX1 030-1 F/N	2CX1 030-1 N/N	2CX1 030-1 F/P
2CH3	2CX1 031-1F	2CX1 031-1 F/N	2CX1 031-1 N/N	2CX1 031-1 F/P
2CH4	2CX1 030-1F	2CX1 030-1 F/N	2CX1 030-1 N/N	2CX1 030-1 F/P
2CH5	2CX1 030-1F	2CX1 030-1 F/N	2CX1 030-1 N/N	2CX1 030-1 F/P
2CH51	2CX1 030-1F	2CX1 030-1 F/N	2CX1 030-1 N/N	2CX1 030-1 F/P
2CH6	2CX1 028-1F	2CX1 028-1 F/N	2CX1 030-1 N/N	2CX1 028-1 F/P

*Supplied with gasket and mounting bolts (m8 x 25 for all except 2CH6, m10 x 25 for 2CH6.)

Silencer Dimensions Table

Part No.	A	B	C	D
2CX 030-1	8" (Approx.)	3.15	1.97	M8/25
2CX 031-1	8" (Approx.)	2.95	1.57	M8/25
2CX 028-1	8" (Approx.)	3.15	1.97	M10/25

THREADED PIPE FLANGE
Part Nos. and Dimensions

Compressor Series	Threaded Pipe Flange*	Dimensions (Inches) A	B	C	D	E
2CH2	2CX1 038	3.94	1½	2.95	.511	M8/25
2CH3	2CX1 037	3.15	1¼	2.95	.511	M8/25
2CH4	2CX1 038	3.94	1½	2.95	.511	M8/25
2CH5	2CX1 038	3.94	1½	2.95	.511	M8/25
2CH51	2CX1 038	3.94	1½	2.95	.511	M8/25
2CH6	2CX1 041	4.41	2	3.35	.630	M10/25

*includes bolts and gasket

HOSE FLANGE
Part Nos. and Dimensions

Compressor Series	Hose Flange*	Dimensions (Inches) A	B	C	D	E
2CH2	2CX1 033	3.93	2.55	2.0	1.83	M8/25
2CH3	2CX1 032	3.34	2.12	1.5	1.43	M8/25
2CH4	2CX1 033	3.93	2.55	2.0	1.83	M8/25
2CH5	2CX1 033	3.93	2.55	2.0	1.83	M8/25
2CH51	2CX1 033	3.93	2.55	2.0	1.83	M8/25
2CH6	2CX1 034	3.93	2.55	2.0	1.83	M10/25

*includes bolts and gasket

How to Specify a Siemens Side Channel Compressor

To specify a Siemens Side Channel Compressor, consult the performance curves on Pages 4 and 5 to determine which basic model best suits your flow and pressure or vacuum requirements. Make allowance for a possible future increase in your requirement if this is at all likely. Refer to the specifications table on Pages 8 and 9 for the model number of the appropriate size unit which matches your available power.

As an example, the requirement is for 60 cfm at a minimum pressure of 50 inches of water. Power available is 230V, 3Ø, 60 Hz. The performance curves show that a 2CH5 machine will satisfy this requirement, it having a rating of 60 cfm and 80 inches of water. The Specifications Table shows Model 2CH5 041-IU is rated for 3Ø 230/460 volts, 60 Hz. Therefore the unit to specify is 2CH5 041-IU.

Next, considering the installation, ascertain whether or not an external silencer is needed. The curves on Page 14 give noise data. Silencer part numbers are listed on Page 11. For silencer consult configuration drawings and specify the one conforming to your application and the appropriate compressor. Obtain the model number from the External Silencer Parts No. Table. For a 2CH5 machine the Silencer would be 2CX1 030-1F, 2CX1 030-1F/N, 2CX1 030-1N/N or 2CX1 030-1 F/P as appropriate.

If hose is to be connected to the compressor directly, specify the appropriate hose flange. If a threaded pipe is to be connected to the compressor, specify the appropriate threaded pipe flange. (It is not necessary to specify the bolts or the gaskets since these are automatically provided as needed with the silencer or flanges.)

Four silencer arrangements are offered to accommodate the requirements of various installations. (See photograph and dimensional drawings.) The hose flanges and threaded pipe flanges used to assemble the units are those illustrated separately. Each configuration is complete with gaskets mounting bolts and the nuts and bolts required to couple the flanges. Other configurations, for instance, pipe flange to pipe flange, obviously can be created. For such special applications, order the basic unit (F) and the components required to create the configuration.

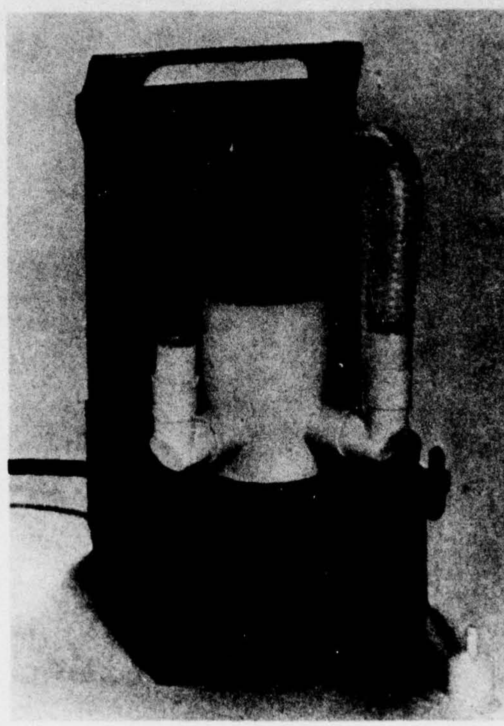
If the equipment being built is for export and requires a motor for operation on electrical power other than 115, 230 or 460 volts, one of the units available on special order may fit. (Some wide range voltage motors are available from stock.) Motors are available on special order at any voltage up to 600 volts for 60 Hz and 590 volts for 50 Hz. For the rare exception custom motors can be manufactured to meet a specific voltage and frequency.

To meet the needs of customers with 208 or 550 volt power a limited quantity of units powered by 3Ø motors for these voltages are kept in stock.

Form A 840 A

DEVILBISS

MANUAL OF INSTRUCTIONS



APPENDIX II-A

65 SERIES

ultrasonic nebulizer®

THE DeVILBISS COMPANY / Somerset, Pennsylvania 15501

DEV ultrasonic nebulizer®*

TABLE OF CONTENTS

INTRODUCTION

Completely transistorized for operational dependability, the Model 65 has the capability of infinitely variable output volumes with a maximum of 6 cc of aerosol per minute. Production of varying volumes of high density, homogeneous particle aerosols make the Model 65 particularly useful in the moisturizing of dry gases associated with intermittent positive pressure and anesthesia procedures. Other uses include periodic aerosol treatment and mist tent therapy.

It is to be noted that another performance specification of the Model 65 relates to its nonfocusing transducer which provides for the complete aerosolization of varying quantities of fluid as measured and placed within the nebulizing chamber. Unquestionably, the exceptional versatility of the Model 65 makes it an important addition to the armamentarium of respiratory therapy.

The Model 65 Ultrasonic Nebulizer is not designed in accordance with electrical standards for "Explosion Proof" applications. Consequently, your attention is directed to the cautionary imprint on the front panel of the nebulizer. It reads; WARNING - DO NOT OPERATE IN A HAZARDOUS ATMOSPHERE NOR WITH FLAMMABLE AGENTS. READ OPERATING MANUAL CAREFULLY.

Careful attention is invited to the installation and operating instructions. They have been provided to insure the satisfaction you have a right to expect from DeVilbiss "Precision Built" products. We also suggest the prompt return of the warranty card to be certain your nebulizer is registered on our records.

GENERAL DESCRIPTION

MODEL 65 (SEE FIGURE 1)

The ultrasonic power section in the Model 65 develops approximately 1,350,000 cycles per second (1.35 MHZ) electrical power which is conducted to a lead zirconate titanate transducer also built in the Model 65. When energized by the high frequency electrical power, the transducer changes its thickness at the frequency of the applied voltage. Water in the couplant compartment transmits the vibrational energy generated by the transducer into the nebulizer chamber atomizing the liquid to be administered into minute droplets.

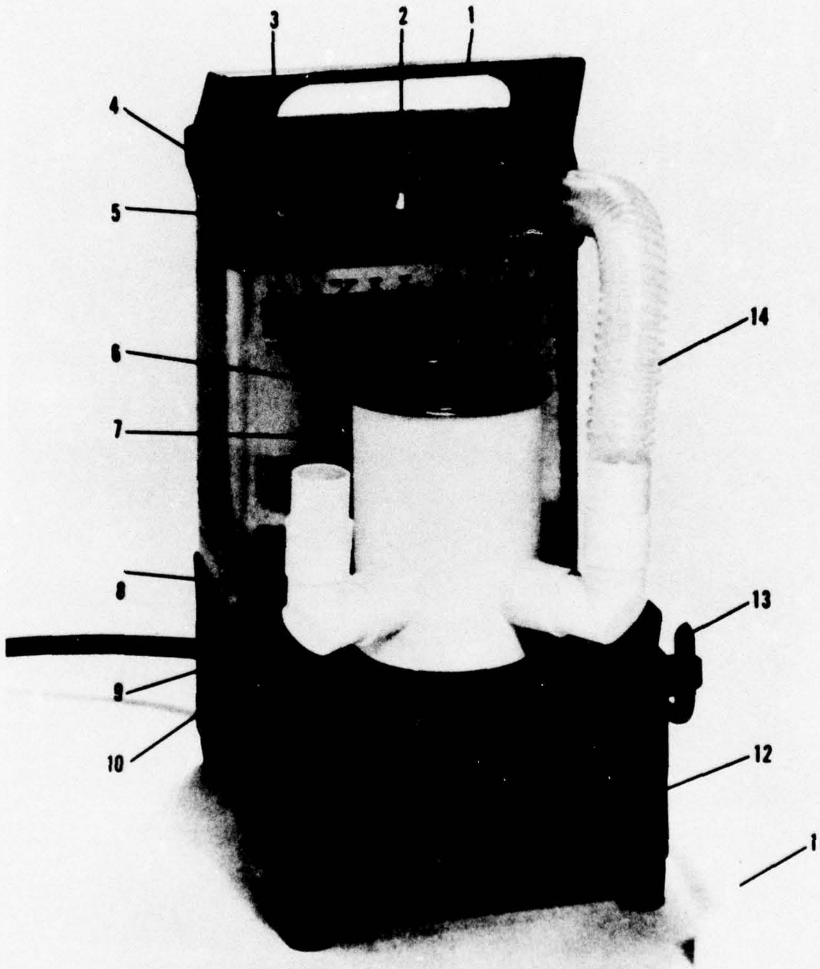
In addition to the self-contained air supply, the carrier gas used to exhaust the aerosol droplets from the nebulizer chamber can be the mainstream gas of of an intermittent positive pressure machine, air from a compressor, or gases from a compressed gas cylinder and anesthesia machine. (Do not use flammable agents.) Central air and gas systems can also be utilized. As with other DeVilbiss ultrasonic nebulizers, it is also possible for the patient to withdraw aerosol from the chamber by his own respiration.

* U.S. Patent 3,387,607; Canadian Patent 777,453; Other patents pending.

OK
mc

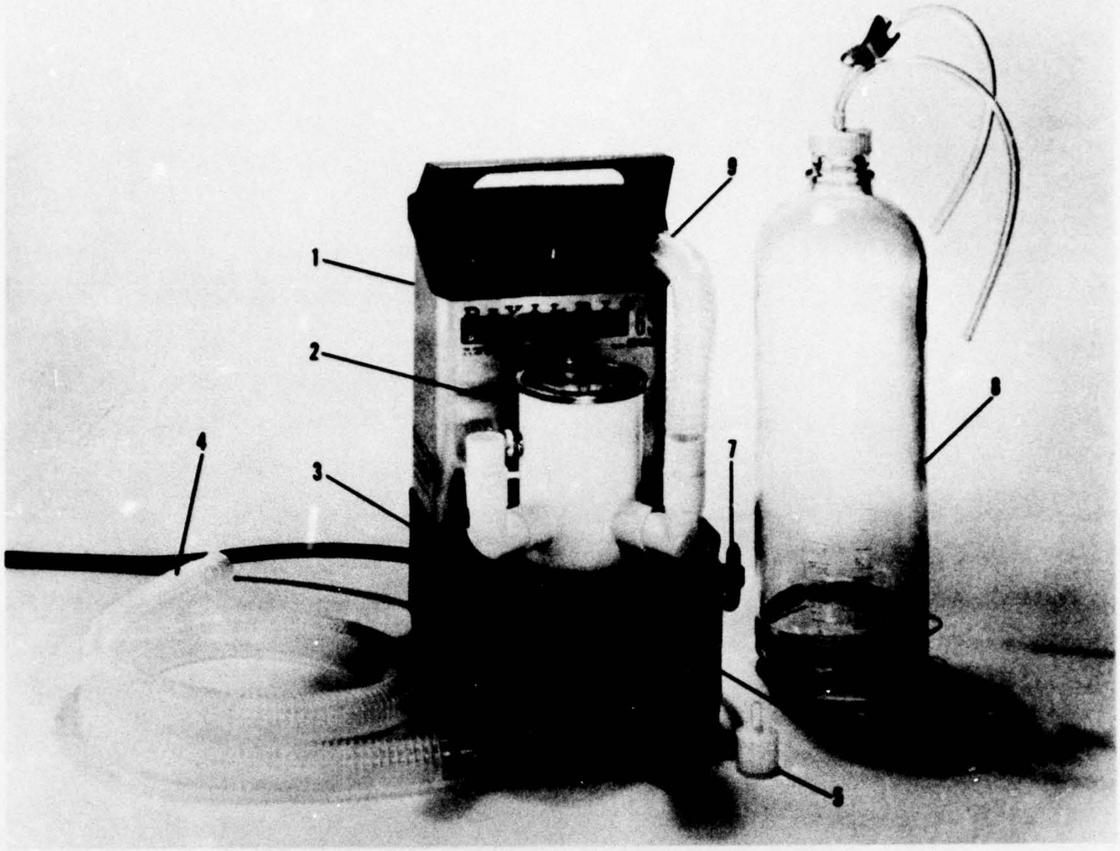
The nebulizer chamber furnished with the Model 65 is designed to receive not more than 180 cc. of nebulizing liquid in a single filling. For prolonged aerosol production, liquid reservoirs and feed systems are available at additional cost. For 1/2 liter reservoir system, order No. 2-1015. For 2 liter reservoir system, order No. 2-1017. Operation of both the limited feed and continuous feed systems is described in this Instruction Manual.

Ultrasonic aerosols differ from those produced by conventional air or gas operated generators. The maximum rate of nebulization possible with this unit is much greater than that of conventional nebulizers. Also the aerosol particles are far more uniform in size resulting in more effective utilization and stability. The ability to adjust aerosol density adds a new dimension to aerosol therapy. Ultrasonic aerosols should be used by or under the direction of a physician.



1. Carrying handle
2. Output control knob
3. Power Switch
4. "Add Couplant" warning light
5. Power pilot light
6. Nebulizer chamber cover
7. Nebulizer chamber
8. Elbow (2 required)
9. Couplant compartment cover (2 required)
10. Couplant compartment water level indicator window
11. Carrier gas adapter
12. Couplant compartment
13. Drain tube
14. Air supply hose

Figure 1. Model 65 Ultrasonic Nebulizer



1. Model 65 Ultrasonic nebulizer
2. Continuous feed nebulizer chamber
3. Couplant compartment cover (2 required)
4. Aerosol hose
5. Carrier gas adapter
6. Couplant compartment
7. Drain tube
8. 2-liter reservoir
9. Air supply hose

Figure 2. Model 6582 Ultrasonic Nebulizer

MODEL 6582 (SEE FIGURE 2)

The Model 6582 consists of the Model 65 nebulizer equipped with a continuous feed nebulizer chamber instead of the single treatment chamber used on the Model 65, and a 2-liter reservoir.

STAND MOUNTED MODELS

In addition to the stand, all stand mounted models include the same basic equipment as the Model 3582A:

Model 65 nebulizer with continuous feed chamber

2-liter reservoir

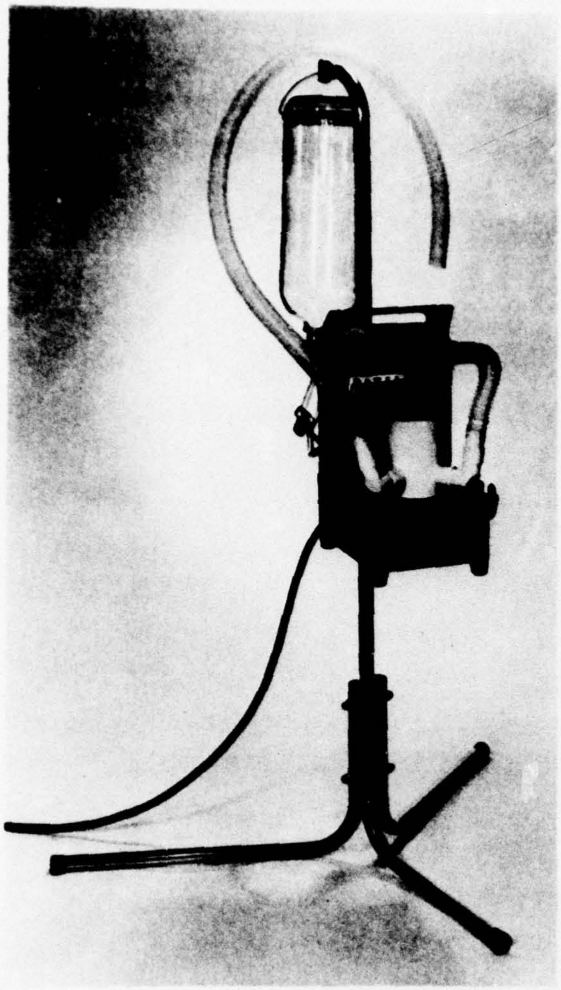


Figure 3. Model 6574 Ultrasonic Nebulizer

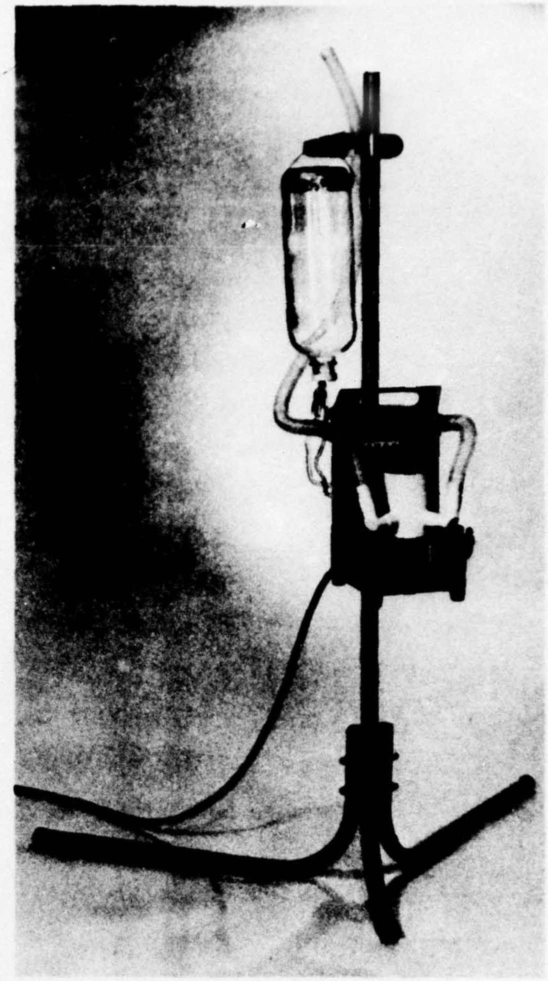


Figure 4. Model 6584 Ultrasonic Nebulizer

MODEL 6574 (SEE FIGURE 3)

The Model 6574 is equipped with an upright, plated steel stand, No. 2-500.

MODEL 6584 (SEE FIGURE 4)

The Model 6584 is equipped with an upright, stainless steel stand, No. 2-502. A canopy frame and tent canopy (No. 2-1014, available at additional cost) can be mounted on the Model 6584A stand.

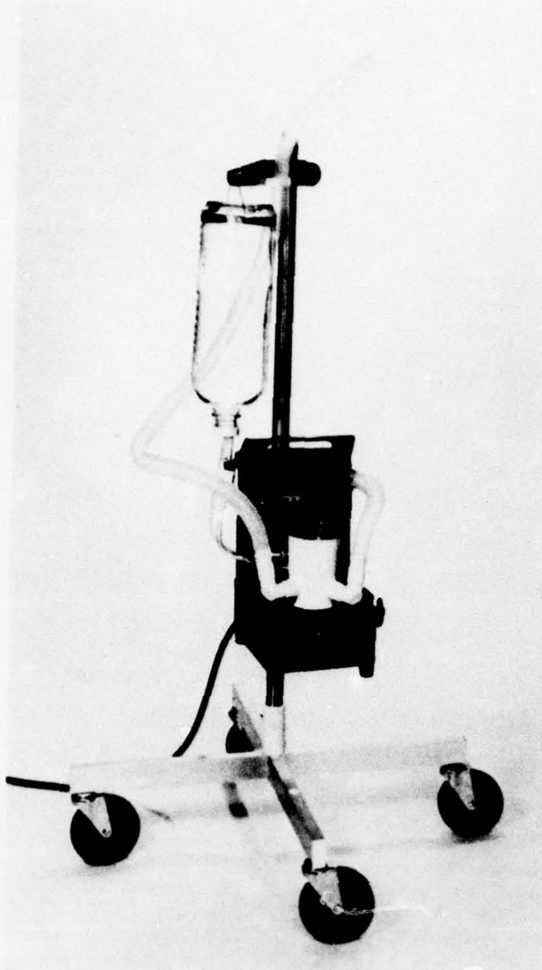


Figure 5. Model 6585 Ultrasonic Nebulizer

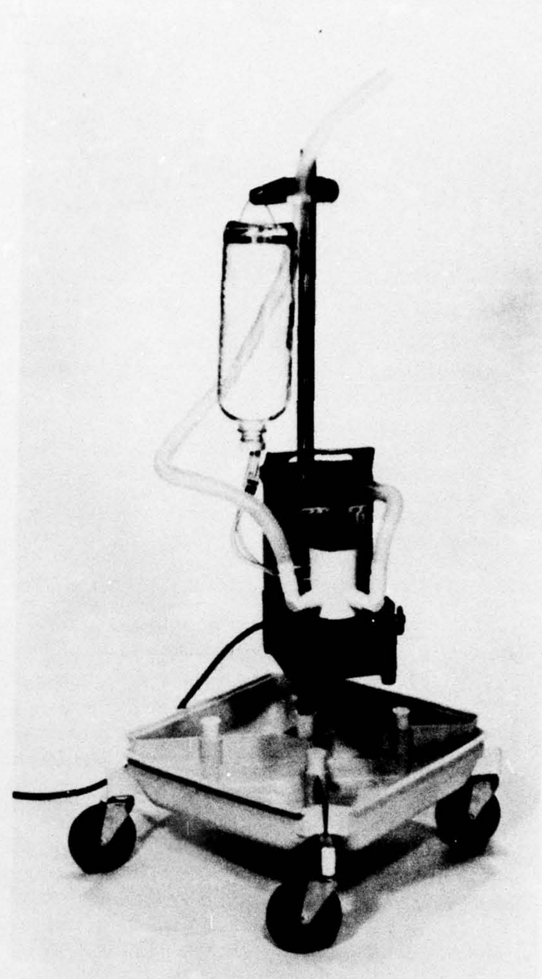


Figure 6. Model 6586 Ultrasonic Nebulizer

MODEL 6585 (SEE FIGURE 5)

A mobile stand, No. 2-503, is furnished with the Model 6585 nebulizer.

MODEL 6586 (SEE FIGURE 6)

The No. 2-504 mobile stand furnished with the Model 6586 nebulizer is equipped with storage trays in the base.

UNPACKING

After unpacking the equipment, examine it for damage which may have occurred in transit. SHOULD ANY SIGN OF DAMAGE BE APPARENT, FILE A CLAIM IMMEDIATELY WITH THE CARRIER STATING THE EXTENT OF DAMAGE.

MODEL 65

1. Bend back the rubber hold down tabs and remove the two couplant compartment cover halves (9, figure 1) from the nebulizer, and check that no foreign material is in the couplant compartment. Clean per cleaning instructions step 1, page 14.

   CAUTION: Do not lift the ultrasonic nebulizer by slipping the hand under the rear of the unit since this may dislodge the air filter or bend the air inlet screen. Always lift by grasping the carrying handle.

2. The unit can be operated while sitting on any convenient table. However, electronic cooling and carrier air enters through the nebulizer base. Therefore, it is important that the nebulizer not be placed on a towel, rug, paper or other material that could restrict air flow.

3. A reversible bracket is provided on the back of the unit for attaching to other equipment (such as the column of an I.P.P.B. machine). To secure the Model 65 to a column proceed as shown in figure 7.

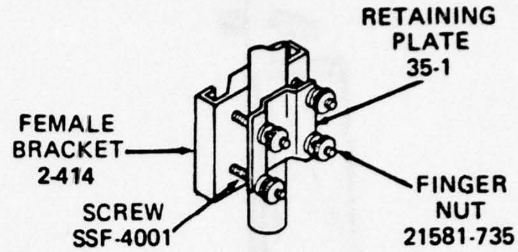
4. Pour room-temperature water into couplant compartment until the float rises and touches the float retaining clip. Be certain that the drain tube is inserted securely into the drain tube clip (See Fig. 8).

   NOTE: The liquid level float switch is a safety feature that allows the unit to operate only when the float is in the raised position. If the water level should fall below a safe level, the warning light (4, Figure 1) will come on and the unit will automatically shut off to prevent internal damage to the unit.

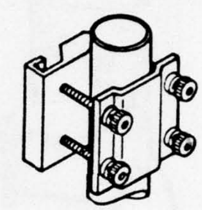
5. Place the two couplant compartment covers around the lower half of the nebulizer chamber (below the elbow outlets and above the bottom flange), and press together until the covers snap into place. (See figure 9).

NOTE: A fill line indicator is installed in the front right corner of the couplant compartment. When the water level reaches this indicator, the liquid level float should be in the proper "on" position. (See Fig. 8)

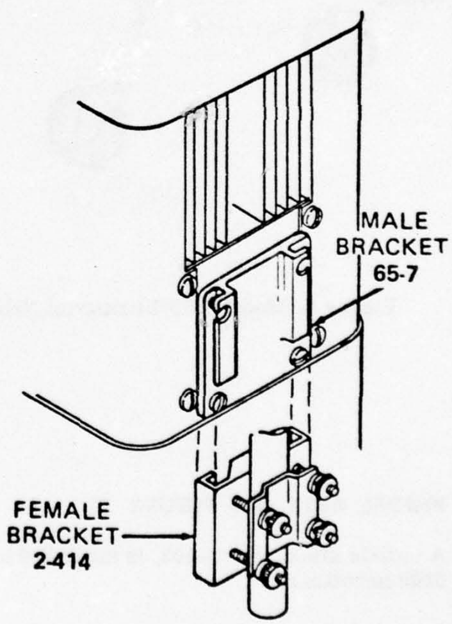
INSTALL BRACKET AND RETAINING PLATE USING ONE OF THE TWO ARRANGEMENTS SHOWN BELOW:



BRACKET ARRANGEMENT FOR COLUMNS UP TO 1 INCH DIA.



BRACKET ARRANGEMENT FOR COLUMNS OVER 1 INCH DIA.



SLIDE MALE BRACKET 65-7 MOUNTED ON 65A NEBULIZER INTO FEMALE BRACKET 2-414 MOUNTED ON COLUMN.

Figure 7. Bracket Arrangements

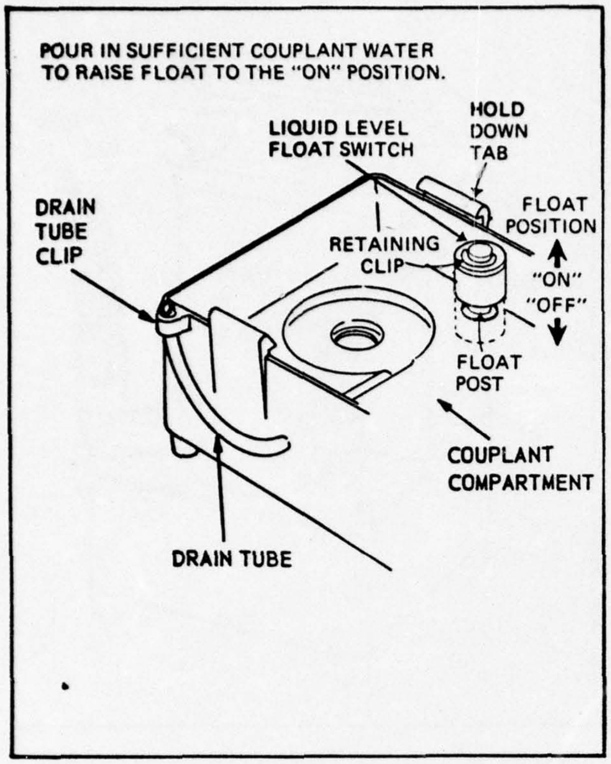


Figure 8. Couplant Water Level

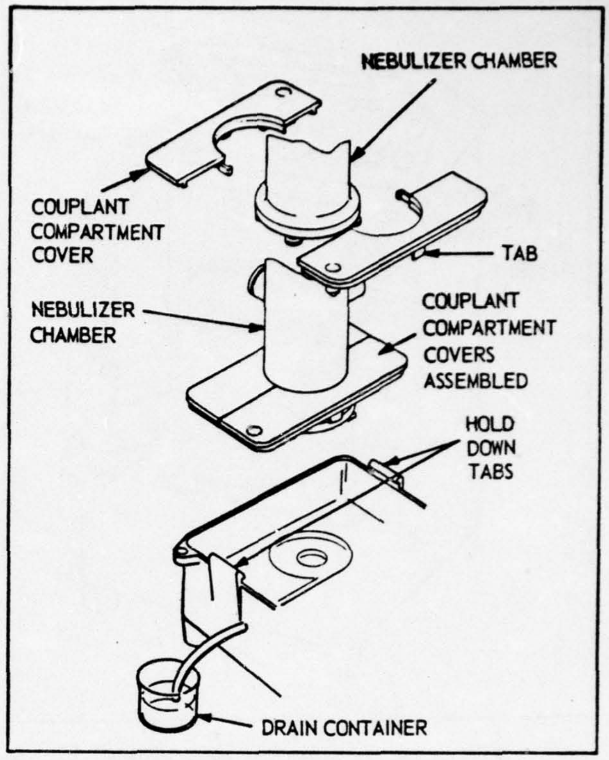


Figure 9. Cover Installation on Nebulizer Chamber

NOTE: When necessary to remove the couplant compartment covers from the nebulizer chamber, grasp each cover with a separate hand. Hold the left hand steady, and twist the right hand vertically clockwise to snap the covers loose. Do not attempt to remove by pulling straight apart.

6. Insert the assembled nebulizer chamber and covers into the couplant compartment by pressing down until the two rubber hold down tabs snap over the covers. Correct assembly configuration is shown in figure 9.

   NOTE: Note that the indicator window (10, figure 1) in each cover will show black when sufficient water is in the couplant compartment. If the water should fall to an unsuitable level, the indicator window will show light.

7. Remove cover (6, figure 1) from top of nebulizer chamber, and pour not more than 180 cc. of liquid in the chamber. Do not allow liquid level to go above the bottom of the elbow ports. (See figure 19.)

8. Check that both elbows (8, figure 1) are firmly installed in the nebulizer chamber.

9. There are various methods available to connect the carrier gas to the nebulizer chamber depending on the equipment being utilized.

   a. When using the self-contained air supply, connect the air inlet and aerosol hoses as shown in figure 10.

   b. When used with I.P.P.B. machines, it is recommended that a check valve be installed in the inlet elbow of the nebulizer chamber (order DeVilbiss Part No. 2-1019). Install the check valve on the inlet elbow (elbow that will receive the carrier gas). (See figure 11.)

      NOTE: Never install check valve on the outlet elbow (elbow that leads to the patient).

   c. For anesthesia machines and similar equipment, connect the carrier gas to the inlet elbow as in figure 12.

   d. For air compressors, central gas systems, compressed gas cylinders, and similar equipment, install the DeVilbiss adapter in the inlet elbow; then, connect the carrier gas to the adapter as in figure 13.

10. Connect a suitable aerosol hose to the outlet elbow, and lead to patient.

11. Connect the power cable to a 115 Volt AC, 60 Hertz, power source. If a three-wire receptacle is not available, use a ground-type adapter with its ground wire secured to the electric ground. The Model 65 is now ready to operate.

AD-A031 864 CINCINNATI UNIV OHIO DEPT OF ENVIRONMENTAL HEALTH F/G 14/2
CALIBRATION SYSTEM FOR DUST SAMPLING.(U)
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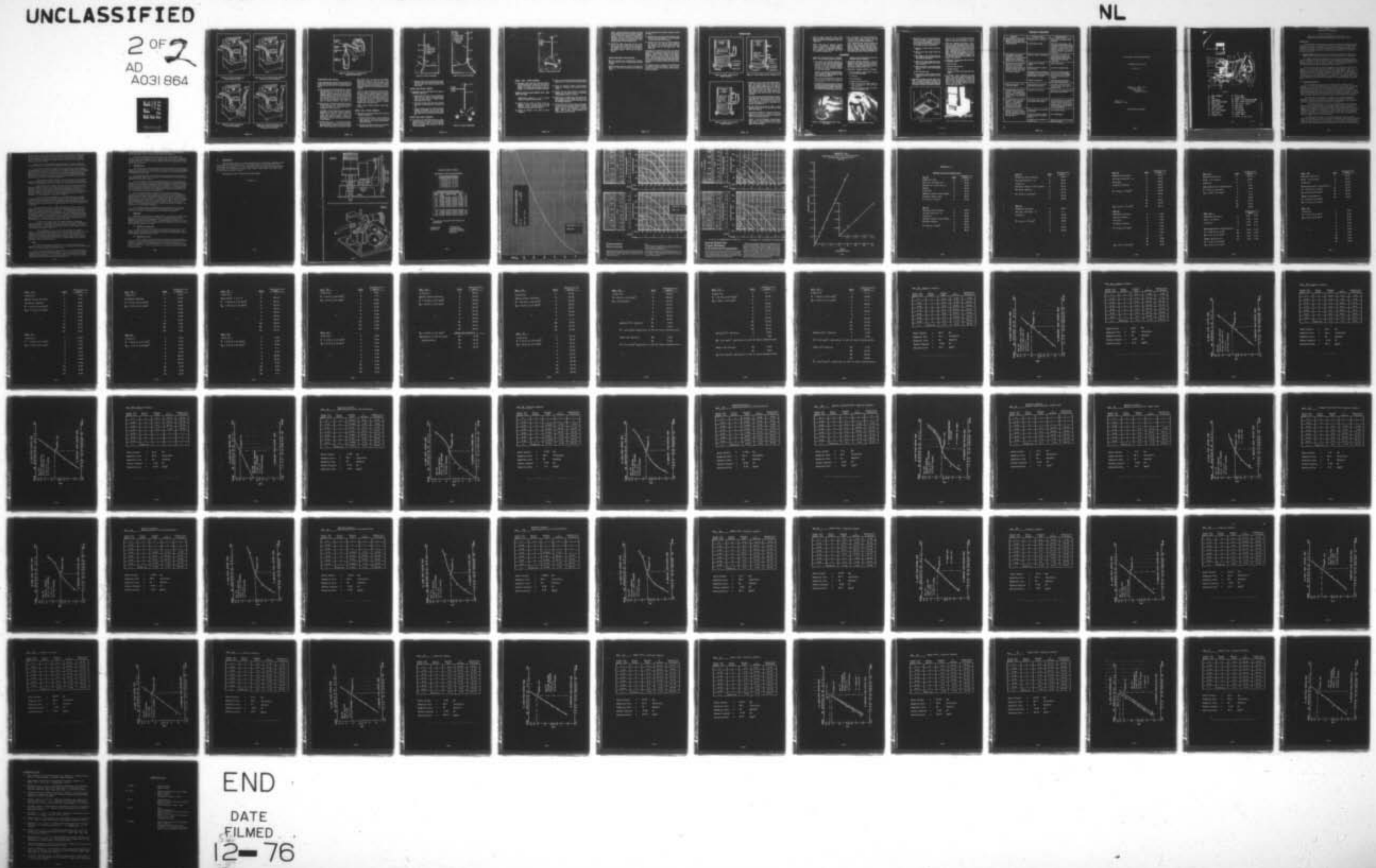

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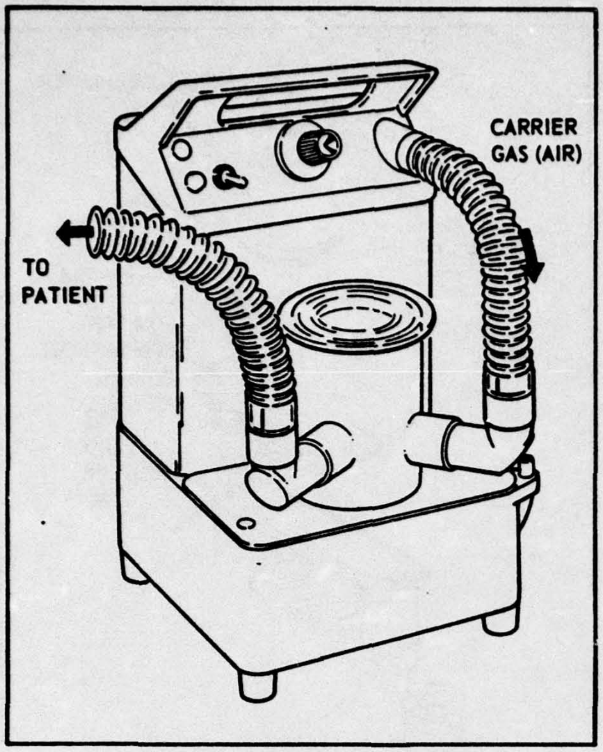

Figure 10. Carrier Gas Hook-up for Self-Contained Air Supply

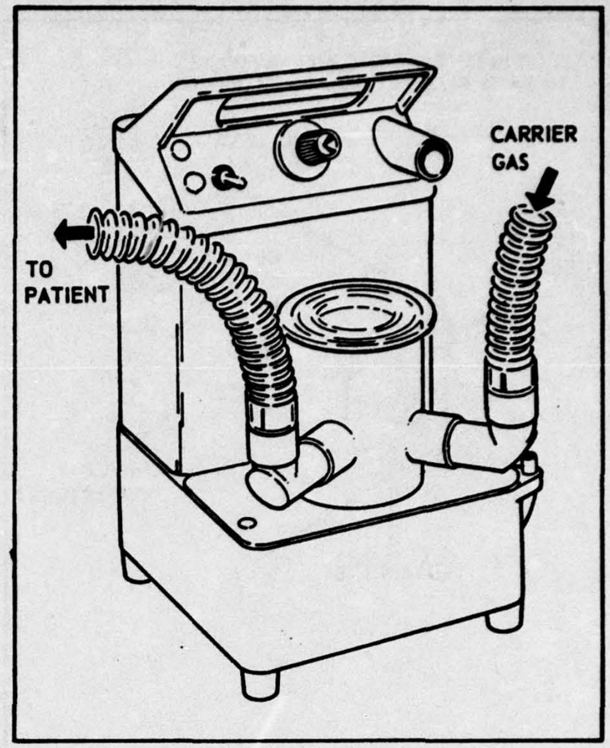

Figure 12. Carrier Gas Hook-up for Anesthesia Machines and Similar Equipment

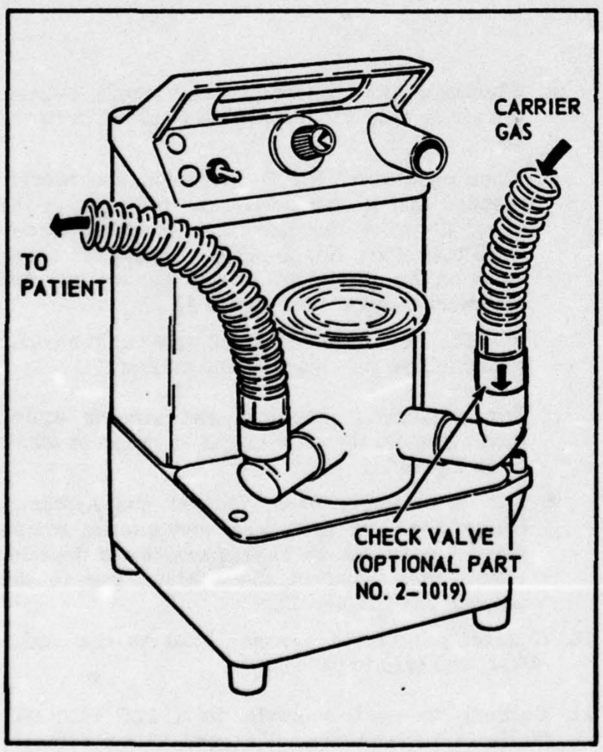

Figure 11. Carrier Gas Hook-up for I.P.P.B. Machines

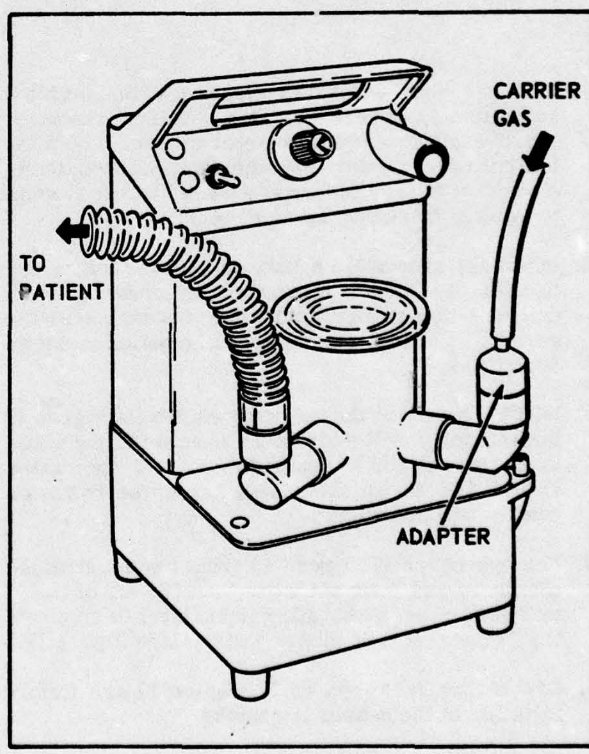

Figure 13. Carrier Gas Hook-up for Air Compressors, Central Gas Systems, and Compressed Gas Cylinders

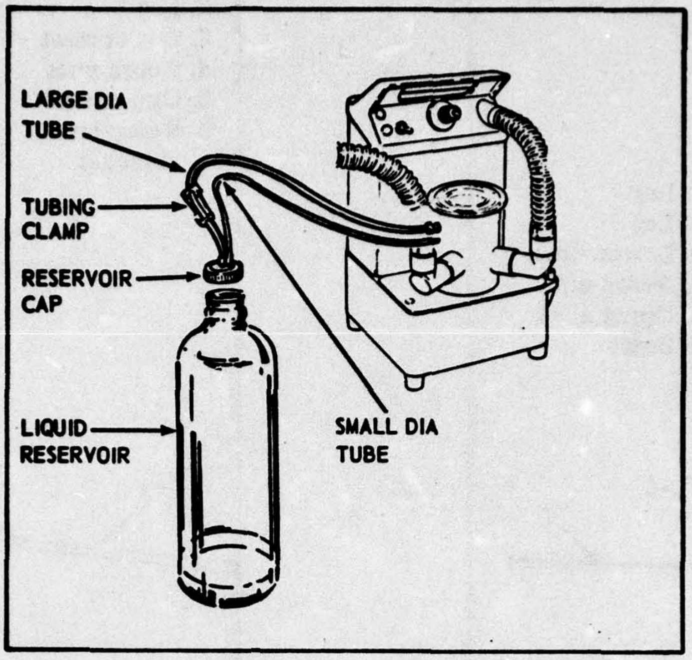

Figure 14. Liquid Reservoir Installation for Continuous-Feed System

CONTINUOUS-FEED SYSTEM

If the continuous-feed system (with the liquid level control in the nebulizer chamber, and liquid reservoir) is to be used, proceed with the remaining installation steps:

12. Remove cap from the liquid reservoir. Connect the small-diameter tube between the smaller-diameter fitting on the cap, and the smaller-diameter (lower) fitting projecting from side of the nebulizer chamber. Be sure that the tubing clamp is on the large-diameter tube; then connect this tube between the larger-diameter fitting on the cap, and the larger-diameter (upper) fitting on side of nebulizer chamber. (See figure 14.)

13. Fill reservoir. Check that tubing clamp is closing off large-diameter tube. Install filled reservoir in cap. (See figure 14.) Then hang reservoir on a suitable bracket near the unit.

    CAUTION: Be sure tubing clamp is closing off large-diameter tube before inverting reservoir. If tube is not closed off, an air or water lock could result that would prevent liquid from running into nebulizer chamber. Be sure that both tubes do not loop down below the top surface of the nebulizer.

14. Release tubing clamp. Liquid will flow through the small-diameter tube to nebulizer chamber. Remove nebulizer chamber cover to observe liquid flow. When the liquid level in the chamber reaches the proper level, as sensed by the chamber liquid level control, the flow will stop. When liquid level in chamber falls, air flows through large-diameter tube into reservoir and allows more liquid through small-diameter tube. Replace nebulizer chamber cover when satisfied that flow is proper.

NOTE: If, after releasing clamp, liquid does not flow into nebulizer chamber, check the small-diameter tube for visible air bubbles. If bubbles are found, try tapping tubes with the fingers to force bubbles out. If not successful, tip reservoir upright, and drain all liquid from tubes (no need to disconnect reservoir). Clamp off large-diameter tube, and invert reservoir. Release tubing clamp; flow should start.

NOTE: When refilling reservoir, follow steps 13 and 14.

MODEL 6574 STAND ASSEMBLY

15. Assemble the Model 6574 stand (No. 2-500) as follows (see figure 15):

    a. Position the stand legs (1 and 2) against the lower mast (3). The leg on the mast and the other two legs should be equally spaced, approximately 120° apart.

    b. Attach the two legs to the lower mast with two threaded studs and four acorn nuts (4).

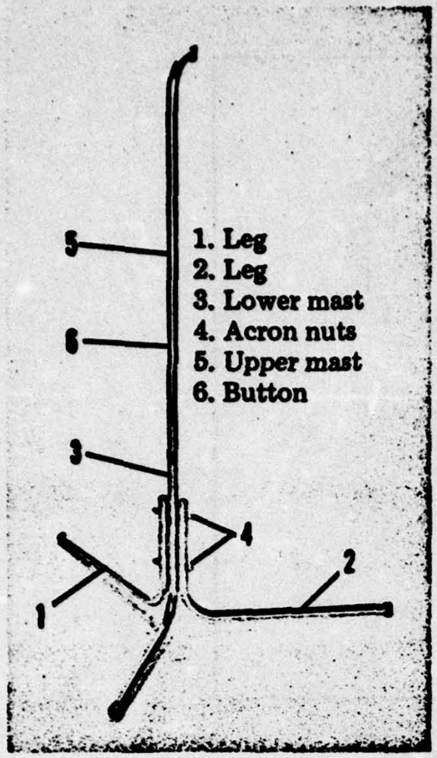

Figure 15. Stand for Model 6574

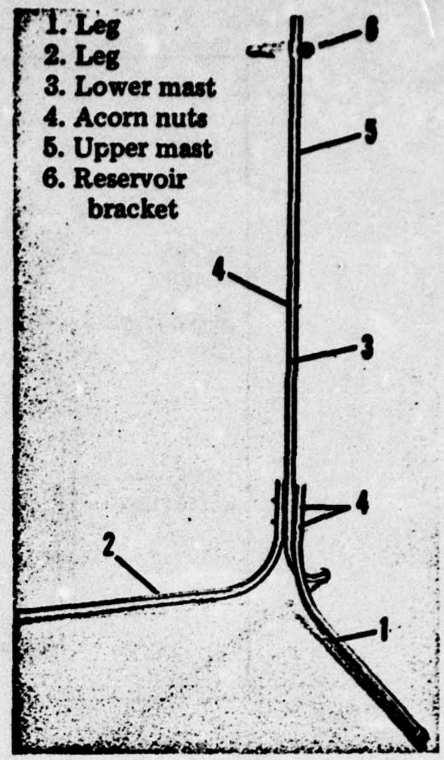

Figure 16. Stand for Model 6584

c. Insert the upper mast (5) into the lower mast and slide it down into position so that the button (6) on the upper mast snaps into the hole in the lower mast.

MODEL 6584 STAND ASSEMBLY

16. Assemble the Model 6584 stand (No. 2-502) as follows (see figure 16):

a. Position the stand legs (1 and 2) against the lower mast (3). The leg on the mast and the other two legs should be equally spaced, approximately 120° apart.

b. Attach the two legs to the lower mast with the two longer threaded studs and four acorn nuts (4).

c. Insert the upper mast (5), with the reservoir bracket (6) installed, into the lower mast. Line up the holes in the upper and lower masts and install the short stud with two acorn nuts (4).

MODEL 6585 STAND ASSEMBLY

17. To assemble the Model 6585 stand (No. 2-503), insert the mast (1, figure 17), with reservoir bracket (2) attached, into the base (3) until the button in the mast snaps into place in the hole in the base upright.

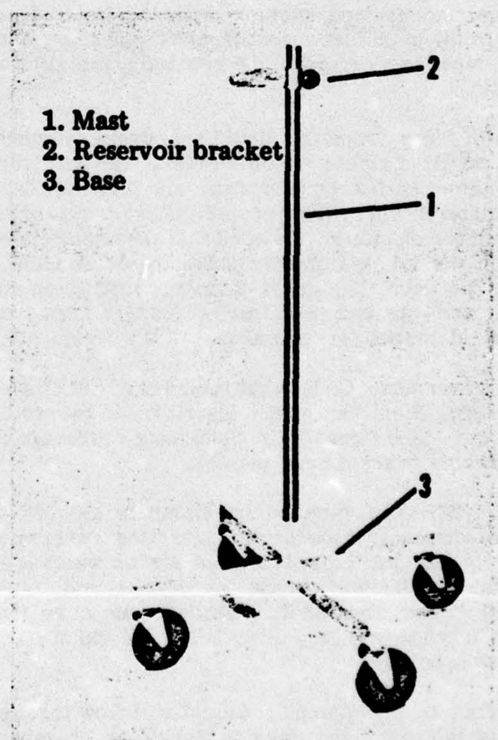

Figure 17. Stand for Model 6585

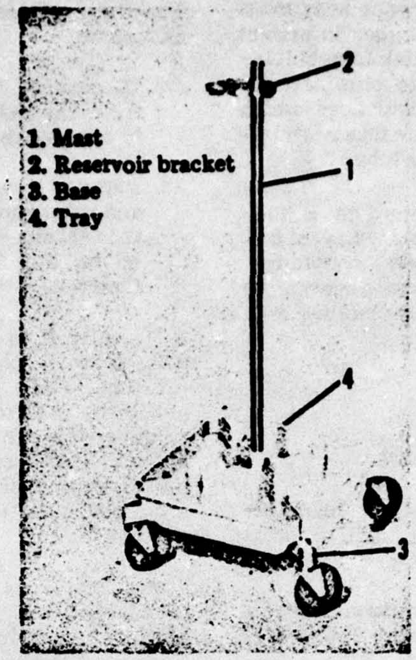

Figure 18. Stand for Model 6586

MODEL 6586 STAND ASSEMBLY

18. The Model 6586 stand (No. 2-504) is assembled by inserting the mast *(1, figure 18), with reservoir* bracket (2) attached, into the base (3) until the button in the mast snaps into place in the base upright. The trays (4) are removable for cleaning.

MODULE INSTALLATION (MODELS 6574, 6584, 6585 and 6586)

NOTE: Refer to figure 3, 4, 5 or 6 for illustration of completely installed model.

19. Remove the two covers (3, figure 2) from the nebulizer module, and check that no foreign material is in the couplant compartment (6). Clean per Cleaning step 1 if necessary.

20. Attach the nebulizer to the mast as shown on figure 7.

21. Pour room-temperature tap water into the couplant compartment in accordance with Installation step 4.

22. Install the nebulizer chamber in the nebulizer module in accordance with Installation steps 5 and 6.

23. Connect the two tubes between the nebulizer chamber and the liquid reservoir in accordance with Installation steps 12, 13 and 14.

24. Connect the air supply hose (the shortest air hose) between the air supply and either of the two nebulizer chamber elbows (depending upon the equipment placement).

25. Connect either end of the aerosol hose (the longest air hose) to the remaining nebulizer chamber elbow. The free end of this hose is for use by the patient; however, for convenience, on Models 6584, 6585 or 6586, it can be engaged in the clamp at the reservoir bracket.

NOTE: *During operation,* the aersol hose must travel upward from nebulizer chamber to patient so that condensation can drain back to nebulizer chamber. Also it is important to eliminate all low spots or loops in the aerosol hose which might block drainback of condensate, thus restricting proper flow of aerosol through tube.

26. Connect the three prong line cord to a 115 Volt AC, 60 Hertz, power source. If a three-wire receptacle is not available, use a grounding-type adapter with its ground wire secured to the electric ground. The unit is now ready to operate.

SINGLE TREATMENT INSTALLATION

Both the standard and continuous-feed nebulizer chambers can be used for nebulizing small amounts of liquid.

With the standard nebulizer chamber furnished with Model 65, proceed in accordance with Installation step 7.

For the *continuous-feed* nebulizer chamber, proceed as follows:

27. Disconnect the large and small diameter tubes from the nebulizer chamber. It is not necessary to remove the liquid level control.

28. Remove cover from top of nebulizer chamber and pour not more than 180 cc's of liquid in the chamber. Do not allow liquid level to go above the bottom of the elbow ports. (See figure 20.)

Frequently it is desirable for aerosol to be administered to the patient on demand or by his own respiration. This technique eliminates any waste of nebulized solution. When utilized in this fashion, remove the air supply hose from the air supply outlet. This disconnects the air supply and prevents the aerosol from being continually delivered into the atmosphere and provides for better quantitative dosage control.

The aerosol chamber is designed for versatility and is adaptable to most techniques. Thus, it is important to carefully follow the physician's prescription and directions.

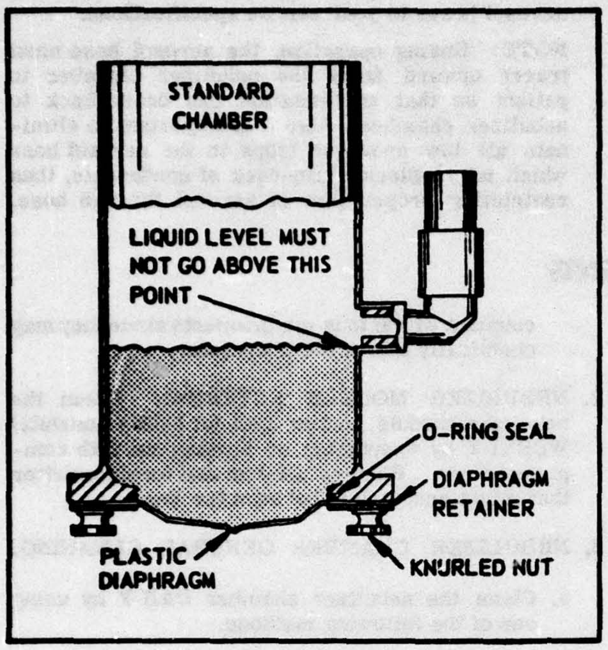

Figure 19. Proper Liquid Level for Single-Treatment

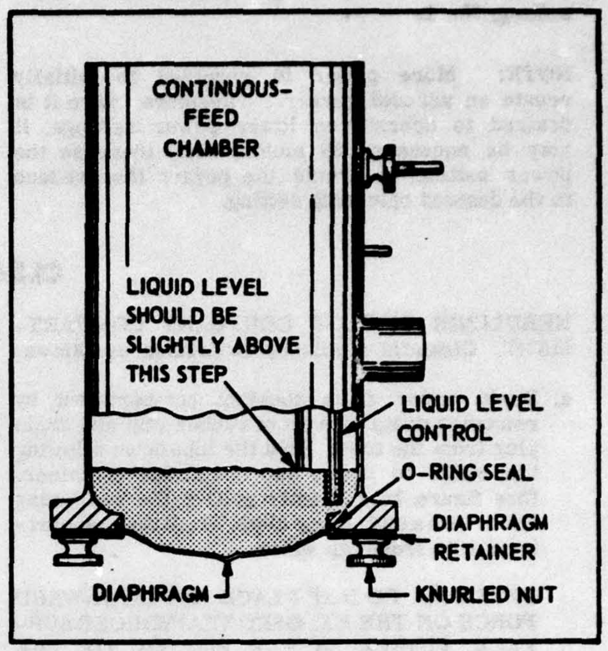

Figure 21. Proper Liquid Level for Continuous-Feed

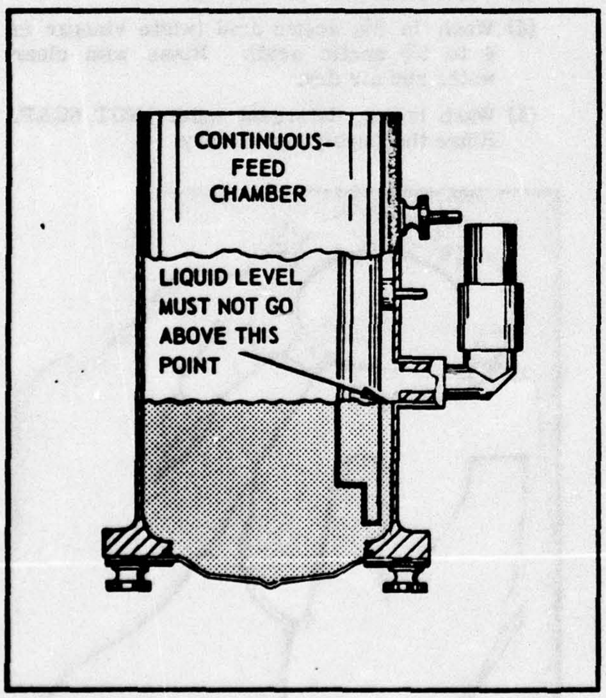

Figure 20. Proper Liquid Level for Single-Treatment

1. **Recheck the water level in the couplant compartment. Be sure the water level is 1/3 of the way up on the couplant sensor cap. (See figure 8.) With the couplant compartment covers installed, the indicator windows (10, figure 1) will show black when water is at the proper level. If indicator window shows light, refill compartment. Periodically check either indicator window during operation.**

2. **Check the liquid level within the nebulizer chamber: For single-treatment, the level should be slightly below the ports. (See figure 19 or 20.) For continuous-feed, the level should be slightly above the second stepped surface of the liquid level control. (See figure 21.)**

3. **Set the output control knob (2, figure 1) of the nebulizer module to No. 10 and turn the switch (3) to "ON" position.**

4. **If properly connected, the power pilot light (5, figure 1) will come on. Evidence of ultrasonic activity can be observed through the transparent cover (6) of nebulizer chamber.**

NOTE: If the "Add Couplant" warning light (4) comes on, it will be necessary to add couplant water (refer to installation step 4) before ultrasonic activity will begin.

5. Also turn output control knob to other visible positions to insure operation on all ranges. No visible aerosol will be generated on the lower setting, No. 1.

NOTE: More power is required to initially create an aerosol geyser. Therefore, when it is desired to operate on lower power settings, it may be necessary to momentarily increase the power setting to create the geyser then reduce to the desired operating setting.

6. If the unit appears to be operating satisfactorily, turn off the power, clean and prepare the liquid reservoir, tubes, nebulizer chamber, air and aerosol hoses to your sterile specifications.

NOTE: During operation, the aerosol hose must travel upward from the nebulizer chamber to patient so that condensation can drain back to nebulizer chamber. Also it is important to eliminate all low spots or loops in the aerosol hose which might block drain-back of condensate, thus restricting proper flow of aerosol through hose.

CLEANING

1. NEBULIZER MODULE COUPLANT COMPARTMENT. Clean the couplant compartment as follows:

   a. Drain water from couplant compartment by removing drain tube from rubber clip and drain plug from the tube. Hold the tube down allowing the water to drain into a suitable container. (See figure 10.) Gently collect the remaining water with a soft, damp cloth. Refill the compartment with fresh tap water.

   CAUTION: DO NOT PLACE ANY DOWNWARD FORCE ON THE EXPOSED TRANSDUCER SURFACE VISIBLE IN THE BOTTOM OF THE COUPLANT COMPARTMENT.

   b. Remove clip and float (See Figure 8). Clean the post and float by wiping with a soft, damp cloth. The hole through the float can be cleaned with a bottle brush.

   c. No special precautions should be taken regarding sterilizing the couplant compartment or couplant water since they are not in contact with liquid or gas emanating from the nebulizer. Care should be exercised in preventing contamination of the couplant by various medicaments since they may chemically attack the transducer.

2. NEBULIZER MODULE EXTERIOR. Clean the nebulizer module cooling fins (at back of module) WEEKLY by vacuuming or blowing out with compressed air. Remove all dust and foreign matter that might accumulate between the fins.

3. NEBULIZER CHAMBER GENERAL CLEANING.

   a. Clean the nebulizer chamber DAILY by using one of the following methods.

      (1) Autoclave.

      (2) Gas sterilization.

      (3) Wash in alcohol and air dry.

      (4) Wash in 2% acetic acid (white vinegar is 4 to 5% acetic acid). Rinse with clear water and air dry.

      (5) Wash in hot, detergent water, NOT SOAP. Rinse thoroughly and air dry.

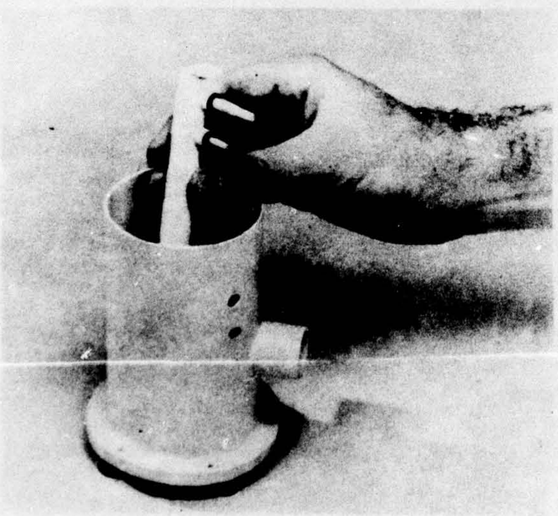

Figure 22. Removing Nebulizer Chamber Liquid Level Control

Figure 23. Removing Diaphragm Retainer

b. Many doctors are recommending that nebulizing equipment be washed or cleaned DAILY with 2% acetic acid (white vinegar) as a preventative measure for pseudomonas. To use this method with the DeVilbiss Ultrasonic Nebulizer, the following procedure is recommended:

(1) Empty the reservoir bottle and nebulizer chamber.

(2) Mix 1/4 cup of white vinegar with 2/3 cup of water.

(3) Put solution in the reservoir bottle and swirl around so that the solution coats the entire inside of the container.

(4) Nebulize the vinegar solution for 15 minutes. If a tent is being used, allow aerosol to go into the tent.

(5) Empty and discard the remaining solution from the reservoir bottle and nebulizing chamber.

(6) Rinse with clear water.

(7) Do not refill the reservoir bottle or couplant compartment until the nebulizer is to be reused.

4. NEBULIZER CHAMBER LIQUID LEVEL CONTROL. If desired the liquid level control can be removed for periodic cleaning. (See figure 22.) Take off the knurled nut projecting through side of chamber and carefully pull control into chamber and out its top. Use a soft thin brush or pipe cleaner to clean the control passages. Reinstall, being sure that both O-ring seals are in place.

5. NEBULIZER CHAMBER DIAPHRAGM. Periodically remove plastic diaphragm at bottom of chamber by loosening the four knurled nuts, and rotating diaphragm retainer until it is free. (See figure 23.) Clean all loose parts in accordance with Cleaning step 3. Inspect diaphragm for pin holes or cracks. Replace diaphragm if pin holes or cracks are found. When reinstalling diaphragm, be sure it is centered on bottom of chamber with its concave (recessed) side facing interior of chamber. Be sure to install O-ring seal between diaphragm and chamber. (See figure 21.)

6. AUTOCLAVE. The following parts can withstand a temperature of 275° F.

a. Liquid reservoir.

b. Reservoir connecting tubes.

c. Nebulizer chamber.

CAUTION: DO NOT AUTOCLAVE THE NEBULIZER.

7. AIR FILTER. Clean or replace the air filter weekly. The air filter "snaps" into place under the rim of the filter retainer on the bottom at the nebulizer base. (See figure 24.) To remove the filter, start at one corner and pull it out from the retainer. When installing the filter, make sure that it "snaps" into place under the rim of the retainer along all four sides.

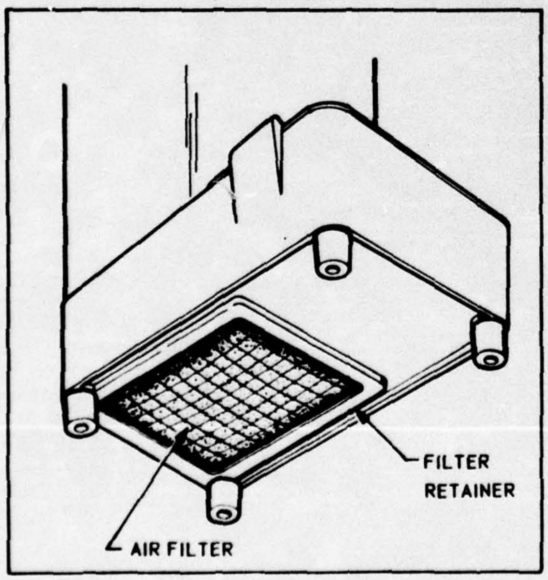

Figure 24. Air Filter

Figure 25. Nebulizer Circuit Breaker Location

TROUBLE SHOOTING

Symptom	Possible Problem	Suggested Check
1. Unit installed and connected as specified, but pilot light does not turn on when switch is turned to the ON position.	Electrical outlet is defective. Circuit breaker tripped.	Check outlet with lamp or other appliance. Reset the circuit breaker. Turn off the power switch and press the red button located at the rear of the nebulizer. (See figure 25.) Turn on the power switch. If the circuit breaker continues to trip, service is needed.
2. Unit installed and connected as specified. Power pilot light turns on, normal ultrasonic activity visible in nebulizer chamber but no aerosol output.	Nebulizer chamber contaminated.	Wash nebulizer chamber and aerosol hose in alcohol or 2% acetic acid (white vinegar is 4 to 5% acetic acid). Rinse with clear water.
3. Unit installed and connected as specified. Power pilot light turns on but there is little ultrasonic activity visible in the nebulizer chamber and aerosol output is low (even when on the No. 10 power setting).	Couplant water excessively aerated. Nebulizer module and couplant water too cold. Diaphragm distored, permitting air bubbles to interfere with proper transmission of vibrational energy into the nebulizer chamber. Couplant contaminated.	Wait for deaeration. Use warmer couplant water. Check to see that diaphragm is properly shaped and installed. Be sure the concave (recessed) side faces the interior of the chamber. Clean couplant compartment, and replace couplant water.
4. Same as sympton No. 3 but at a low power setting.	Power setting too low to start and establish nebulization.	Turn output control knob to No. 10 power setting, then reduce to desired setting.
5. Unit installed and connected as specified. Power pilot light turns on. "Add Couplant" light is on and there is no ultrasonic activity visible in the nebulizer chamber.	Insufficient couplant water.	Add water to the couplant compartment (See Installation Step 4).
6. Unit installed and connected as specified. Power pilot light turns on. "Add Couplant" light is off but there is no ultrasonic activity visible in the nebulizer chamber.	Power supply overheated and its thermostatic control opened.	The cooling air has been restricted (refer to Installation, step 2) or cooling fins need cleaning (refer to Cleaning, step 2). The switch will reset when the equipment returns to room temperature.
7. Liquid reservoir filled and properly connected to nebulizer chamber, but chamber does not fill. (For CONTINUOUS-FEED SYSTEM ONLY.)	Foreign material or air bubbles in feed tubes. Liquid level control in nebulizer chamber plugged with foreign material. Air leaks at tube connections or reservoir cap.	See Assembly step 14. See Cleaning step 4. Tighten all connections by pushing tubes into fittings.

THE WRIGHT DUST FEED MECHANISM

INSTRUCTIONS FOR USE

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London, N.W.10.

Issue No. 3.
September, 1964

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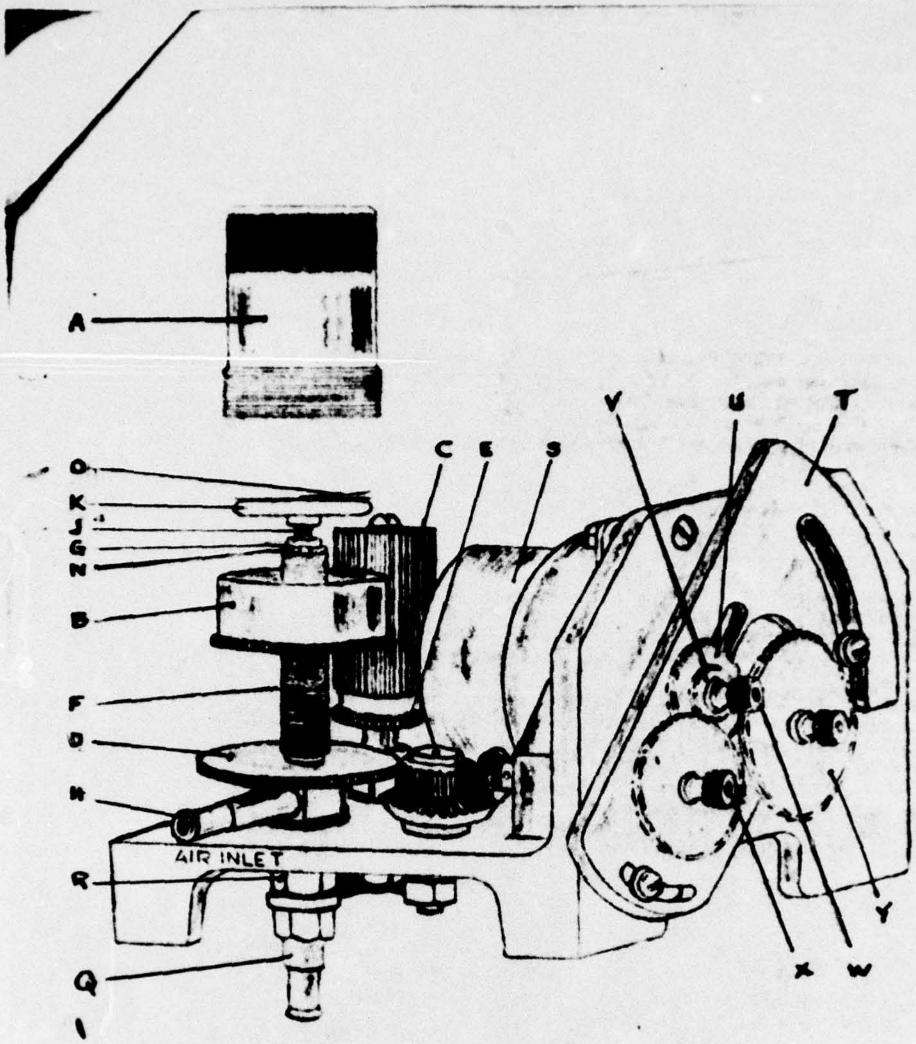

FIG 1

A	Dust container	N	Spring ring
B	Cap	O	Scraper blade
C	Long pinion	Q	Outlet nozzle (containing baffle)
D	Gear on threaded spindle	R	Main spindle clamping nut
E	Small pinion	S	Synchronous motor
F	Threaded spindle	T	Gear plate
G	Main spindle	U	"Driven" gear
H	Air inlet connexion	V	"Driving" gear
J	Dust tube	W	Counter shaft
K	Scraper head	X	Cross shaft
		Y	Motor spindle gear

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INSTRUCTIONS FOR THE USE
OF THE
WRIGHT DUST FEED MECHANISM

(See Journal of Scientific Instruments, 27, 12, 1950 and Review of Scientific Instruments, 34,9, Sept. 1963 p. 1023-5)

INTRODUCTION

This mechanism has been designed to operate reliably for long periods with a minimum of attention, and it will be found that it will do so provided certain precautions are taken. Experience has shown that breakdowns are nearly always the result of a defect in either the compressed air or the dust or in both, and therefore considerable attention is given in these instructions to the control of these two factors.

1. ASSEMBLY INSTRUCTIONS (In these and in subsequent instructions reference is made to Figure 1 for identification of the various parts of the mechanism).

In order to avoid risk of damage in transit, the dust container 'A' and cap 'B', together with the scraper head 'K', are removed from the mechanism and packed separately, and the air inlet connexion 'H' which normally protrudes beyond the edge of the main frame is turned so that it is contained within it. The mechanism should therefore be assembled for use as follows:-

First slack off the main spindle clamping nut 'R' and rotate the air inlet until it is in its correct position as shown in the illustration. (If it is desirable, for any reason, the inlet can be put at right angles to this position). Tighten the clamping nut again a little more than finger tight. Next pull up long pinion "G' so as to disengage pinion 'E' from gear 'D'. Cap 'B' should then be screwed on to the threaded spindle 'F', care being taken that the gear teeth on the periphery of the cap engage with the pinion 'C'. The scraper head 'K' may now be screwed on to the end of the dust tube 'J' and the mechanism is ready for use.

2. OPERATING INSTRUCTIONS

(a) The mechanism can be used with either the full capacity of the container 'A' or with the aluminum liner in position so as to reduce its internal diameter to half an inch, which will have the effect of reducing the capacity of the container eight times. If this is done, the small scraper head must be substituted for the normal one. The size of the container to be used will depend upon the concentration required and the period for which the mechanism is to run. A more uniform cloud will be obtained with the mechanism running fast, so that the larger container should only be used for long runs or very high concentrations.

(b) The rate of feed required to produce a given cloud concentration will depend upon the size analysis of the dust and can only be determined by experiment. Once this has been found however, the concentration can be altered at will by adjusting the rate of rotation of the container.

The synchronous motor 'S' runs at a constant speed of one revolution per minute and a large range of variable speeds between the motor and the cross shaft 'X' may be selected by means of the gears supplied with the mechanism. Examples of the gear ratios available are shown on the attached table. The gear referred to as "driven" is that marked 'U' in the diagram, and that referred to as "driving" is marked 'V'. The gearing between the cross shaft and the downward feed of the dust container is such that 30 turns of the cross shaft equal 1/26" (1 m.m.) downward feed of the dust container.

(c) Having determined the rate of feed required and selected suitable gears from the table, the plate 'T' should be slackened by undoing the two securing screws and swung clear of the motor spindle. Any of the gears can be fitted on to any of the three spindles (the knurled screws on which are also interchangeable) except that the largest gear with 76 teeth must not be fitted to the motor spindle.

The gear for the motor spindle should be placed in position first, followed by the two gears on the counter shaft 'W'. Finally, the gear should be placed on the cross shaft and the counter shaft moved until the driving gear 'V' meshes with it. The plate should then be swung until the driven gear 'J' meshes with the gear on the motor shaft.

A small amount of play should be allowed between the gears, in order to ensure that they are not too deep in engagement, which will cause undue friction.

(d) To fill the container, pour the dust in a little at a time, ramming it down with the rammer after each addition. The ramming should be done vigorously and it will then be found that the dust packs to a constant density which is usually about half that of the material of which it is composed, although this is much affected by the fineness of the dust. From this and the information given above about the rate of feed, it is possible to calculate approximately the gravimetric concentration of the cloud that will be produced.

The dust can be packed to within 8 m.m. of the mouth of the container, giving a maximum working distance of 36 m.m. The effective volume of the large container is approximately 40 cu.cm., reduced to 5 cu.cm. when the liner is fitted.

Having packed the container, screw the cap 'B' up to the top of the threaded spindle 'F' as far as it will go, and then screw the container 'A' into the cap. Care must be taken not to over-fill the container or it will not be possible to screw it into position. Screw the container down gently until a slight resistance is felt, indicating that the scraper head 'K' is in contact with the dust. Push down the pinion 'C' so as to engage the small pinion 'E' with the wheel 'D'. The mechanism is then ready to operate.

It can be tested by connecting to a suitable compressed air supply, as described below, and then disengaging the driving gear and rotating by hand. A visible cloud should emerge while the mechanism is being rotated and should cease as soon as it is stopped. If a cloud emerges when the container is not being rotated, the dust has not been packed tightly enough, or else it is too coarse to be suitable.

(e) The mechanism should run without attention until the container is empty, when the teeth on the cap 'B' will travel beyond the pinion 'C', so that although the container continues to rotate, it is no longer being fed down and there is no danger of damage from over-loading. If a blockage occurs for any reason when the mechanism is running the motor may stall. This condition should be avoided as damage to the motor may result. At low speeds however the pressure of the scraper head on the dust will force the spring ring 'N' off the end of the main spindle 'G', allowing the gear 'D' to be lifted out of engagement with the driving pinion, so that the mechanism automatically stops.

Although this safety device will usually prevent it, damage may occasionally occur to the scraper blade 'O', which is also liable to be worn away after prolonged use. Replacements can be obtained from the makers. The shape of the scraper blade has been found by experience to give the best results and it is not advisable to attempt to alter it.

If the mechanism is to be used for supplying dust to an animal chamber, it can be conveniently placed on top of it, as shown in Figure 2, with the nozzle 'Q' projecting into the chamber. When it is necessary to control the concentration accurately, the nozzle should be sealed in with a rubber ring or plasticine. For experimental purposes however, it can conveniently be placed on the bench in the position shown in Figure 3, and connexion made to any suitable apparatus by means of rubber tubing.

3. DUST

(a) The dust used must be fine ground, i.e. the great majority of the particles less than 20 microns in diameter. This is necessary to ensure that the dust will form a stable cake which will not blow away.

(b) It must be remembered that all the dust in the container has to pass through the jet, which has a diameter of 0.052" (1.3 m.m.), so that the presence of one particle too big to do so is certain to cause a stoppage sooner or later. Therefore all dusts should be sieved through about 60 mesh if there is any doubt about their freedom from even a few oversize particles.

(c) Dusts which are very hygroscopic cannot be used unless special precautions are taken to dry the compressed air completely. In addition, it may be necessary to place a heating element round the container.

(d) Dusts which contain many fine fibres, e.g. cotton fibres from a new bag filter, are difficult to use for long periods, as the fibres accumulate in the scraper and eventually clog it. Sometimes the fibres can be removed from the dust by calcining it but if this is liable to affect its properties, a fresh sample must be obtained.

4. <u>COMPRESSED AIR</u>

(a) The quality of the compressed air used is probably the most important factor in the performance of the mechanism. Fine dust is extremely easily rendered indispersable by either water or oil, and compressed air laid on in laboratories very commonly contains both.

(b) Excess moisture can be removed from the air either by means of the usual dehydrating agents, e.g. silica gel, or by cooling the air to or below room temperature while under pressure.

(c) Most rotary or piston type compressors deliver a fair amount of oil with the air, in the form of a very fine aerosol which will pass most commercial filters and travel along a considerable length of piping, but tends to be absorbed by the dust in the tube and eventually clogs the mechanism. It can be filtered out with ordinary filter paper, which will last as long as it is not sodden with oil. It is better, however, to use a completely dry blower of the Rootes' type or, for short runs, a cylinder of compressed air.

(d) The pressure required depends upon the volume of air used. A pressure of 10 lb./sq.in. gives a flow of 20 litres/min. with the standard jet. The mechanism will operate satisfactorily with flows as low as 10 litres/min. or as high as 40. Too low a flow leads to blockage of the scraper, while too high causes the dust to blow away before it is scraped off. Most of the air resistance of the mechanism lies in the jet, so that if a larger volume of air is required than can be obtained with the air pressure available, a larger jet should be fitted. It is not advisable to work with a lower pressure than 3 lb./sq.in., as the dust will be incompletely dispersed.

(e) A pressure gauge and flowmeter should be fitted in the air supply and if the air flow is maintained with a normal pressure and the container is rotating, the mechanism can be assumed to be operating satisfactorily.

5. <u>BREAKDOWNS</u>

Apart from electrical and air supply failures, two types of breakdown may occur. In both cases the result is a cessation or reduction of the air flow, followed by a stoppage of the mechanism. It is essential to realize that a mechanical stoppage is always secondary, the power required to scrape up the dust when an adequate stream of air is passing through the mechanism is very small and well within the capacity of the motor.

(a) <u>Blockage of scraper only</u>.

This is almost invariably due to the presence of oil or water in the air or of fibres in the dust, the prevention of which is described above. The scraper can be readily cleared with a piece of wire or, if necessary, the blade 'O' can be removed by undoing the two screws.

(b) <u>Blockage of the jet</u>.

This is almost invariably due to the presence of oversize particles in the dust. It is important to realise that it may cause blockage of the scraper as well, as a result of the reduction in air flow, so that if the scraper is found to be blocked, the jet should be examined to see that this is not the cause. To do so, unscrew the nozzle 'Q', when the jet will be found screwed into the end of the outlet tube.

6. MAINTENANCE

The mechanism should be oiled occasionally at the points indicated with a few drops of light spindle oil. The baffle plate in the nozzle 'Q' will eventually wear through, at a rate depending upon the nature of the dust used, (in normal use, operating 20 hours a day, with a fairly soft dust like coal, it will last for about a year).

Replacements can be obtained from the makers.

-oOo-

FIG. 2.

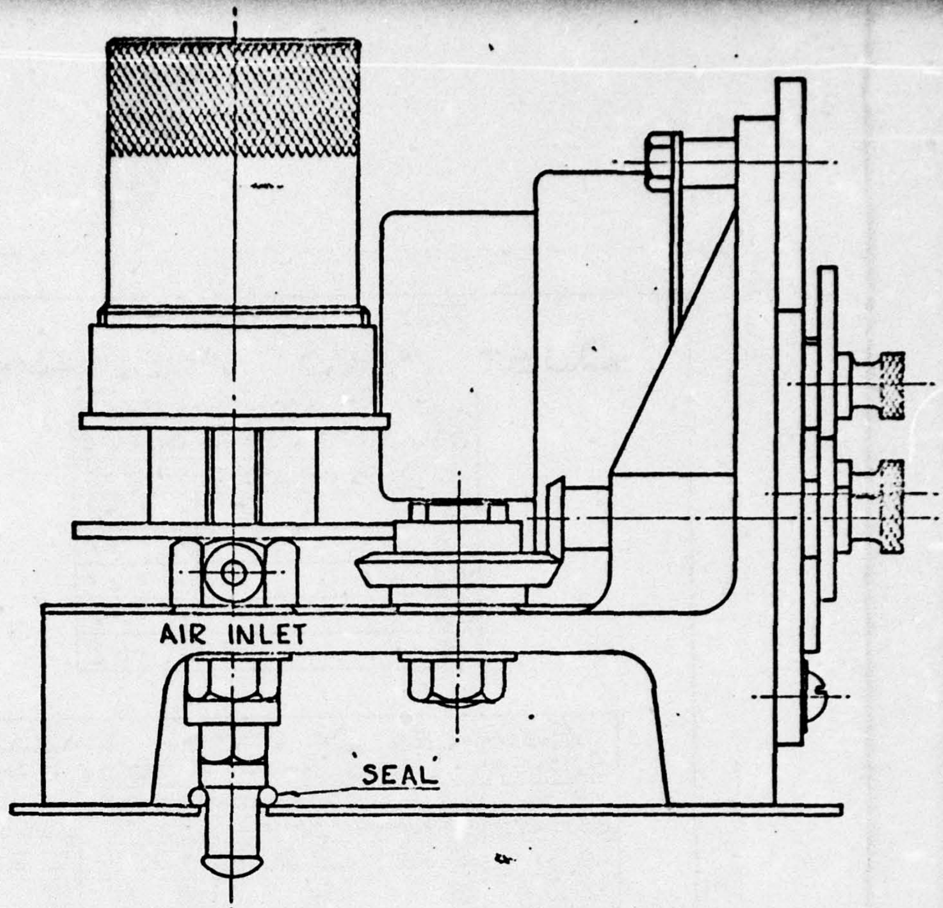
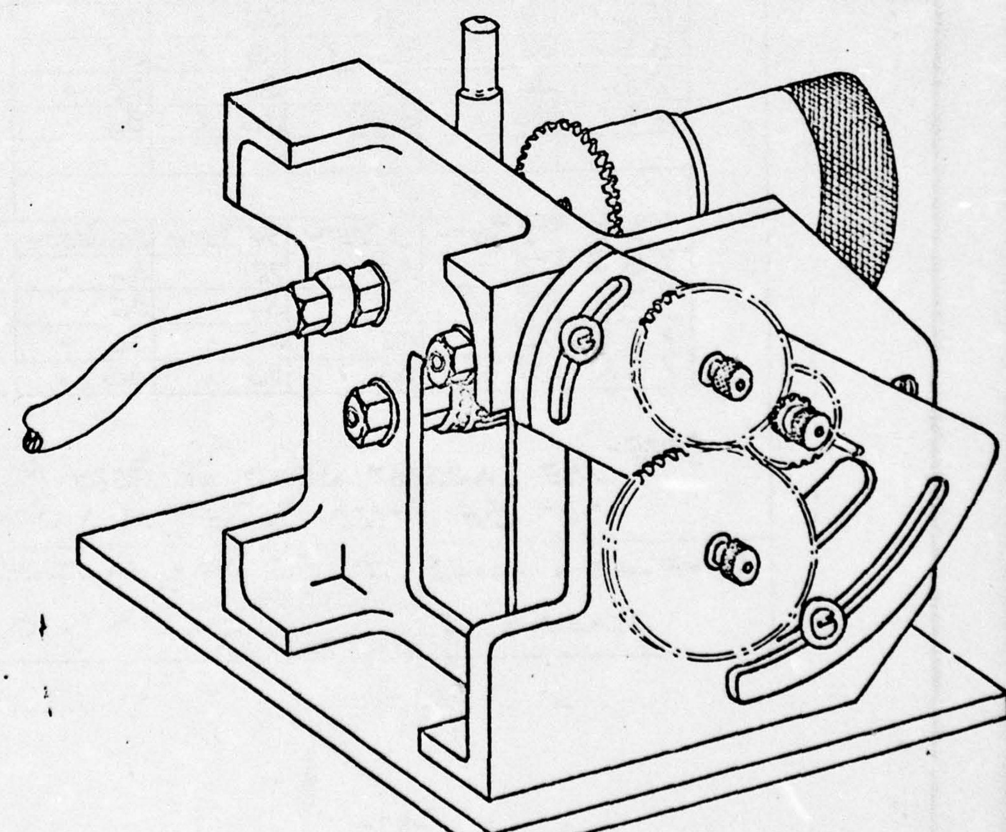


FIG. 3



GEAR RATIO TABLE

THE WRIGHT DUST FEED MECHANISM

LIST OF INTER-CHANGEABLE STANDARD GEARS SUPPLIED	
76 Tooth Spur Gear	No. off:-1
72 Tooth Spur Gear	No. off:-2
68 Tooth Spur Gear	No. off:-1
54 Tooth Spur Gear	No. off:-1
36 Tooth Spur Gear	No. off:-4
18 Tooth Spur Gear	No. off:-2

EXAMPLES OF RATIOS AVAILABLE BETWEEN CROSS SHAFT & MOTOR SPINDLE

Ratio Required	Gear on Motor Spindle	Intermediate Gears Driven	Intermediate Gears Driver	Gear on Cross Shaft	
16 to 1	18 Teeth	68 Teeth	18 Teeth	76 Teeth	DECREASED SPEEDS
12 to 1	18 Teeth	54 Teeth	18 Teeth	72 Teeth	
8 to 1	18 Teeth	36 Teeth	18 Teeth	72 Teeth	
6 to 1	18 Teeth	54 Teeth	36 Teeth	72 Teeth	
5 to 1	18 Teeth	68 Teeth	54 Teeth	72 Teeth	
4 to 1	18 Teeth	36 Teeth	36 Teeth	72 Teeth	
3 to 1	36 Teeth	36 Teeth	18 Teeth	54 Teeth	
2 to 1	36 Teeth	36 Teeth	36 Teeth	72 Teeth	
1 to 1	36 Teeth	36 Teeth	36 Teeth	36 Teeth	

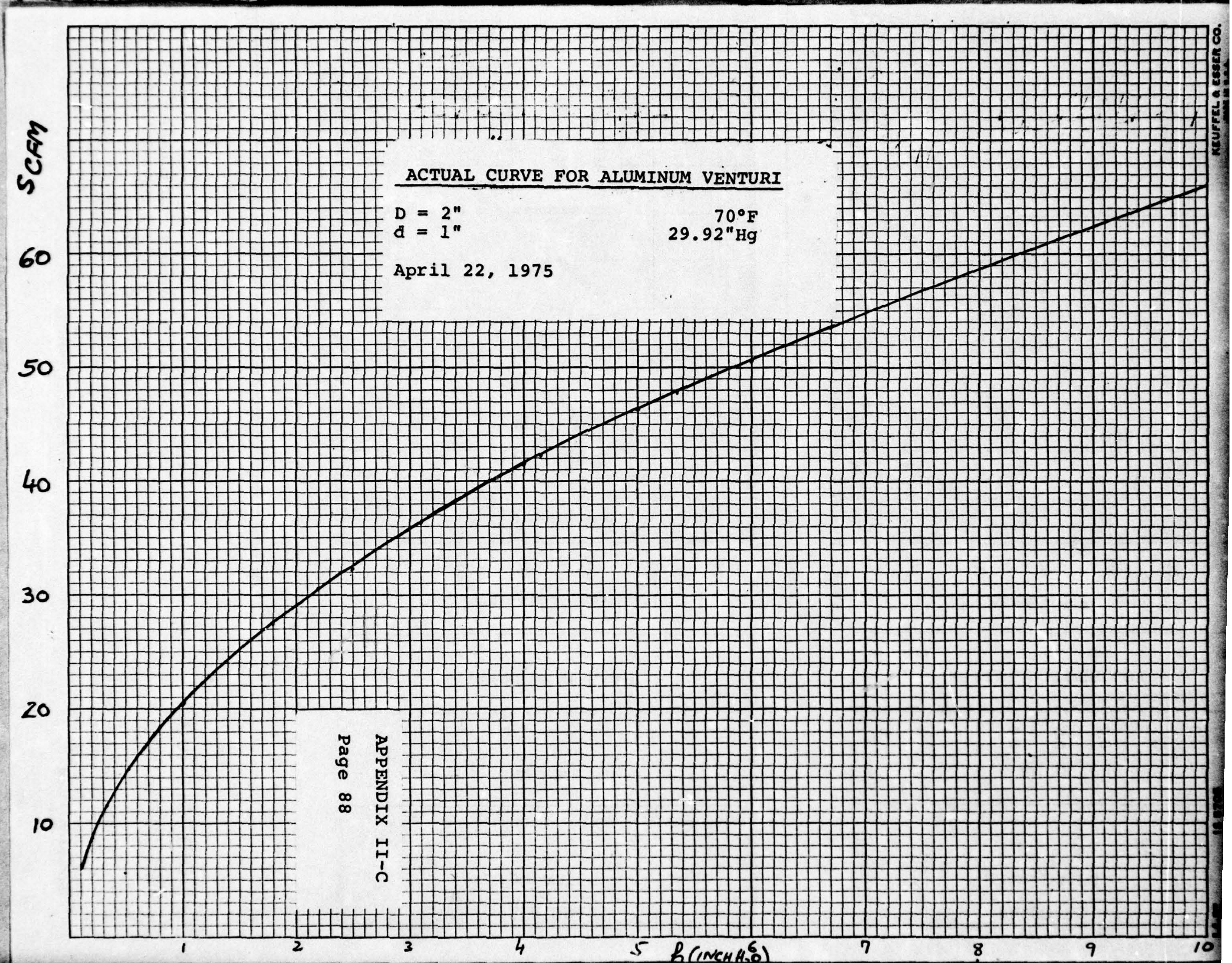
1 to 6	72 Teeth	18 Teeth	54 Teeth	36 Teeth	INCREASED SPEEDS
1 to 4	72 Teeth	36 Teeth	72 Teeth	36 Teeth	
1 to 3	72 Teeth	36 Teeth	54 Teeth	36 Teeth	
1 to 2	72 Teeth	36 Teeth	36 Teeth	36 Teeth	
1 to 1.5	54 Teeth	36 Teeth	36 Teeth	36 Teeth	

Note:

The largest gear 76 teeth *MUST NOT* be fitted to the Motor Spindle

Compiled by sole Manufacturers

L. ADAMS LTD.
22, MINERVA ROAD
LONDON, N.W.10 6HS
ENGLAND



APPENDIX II-C

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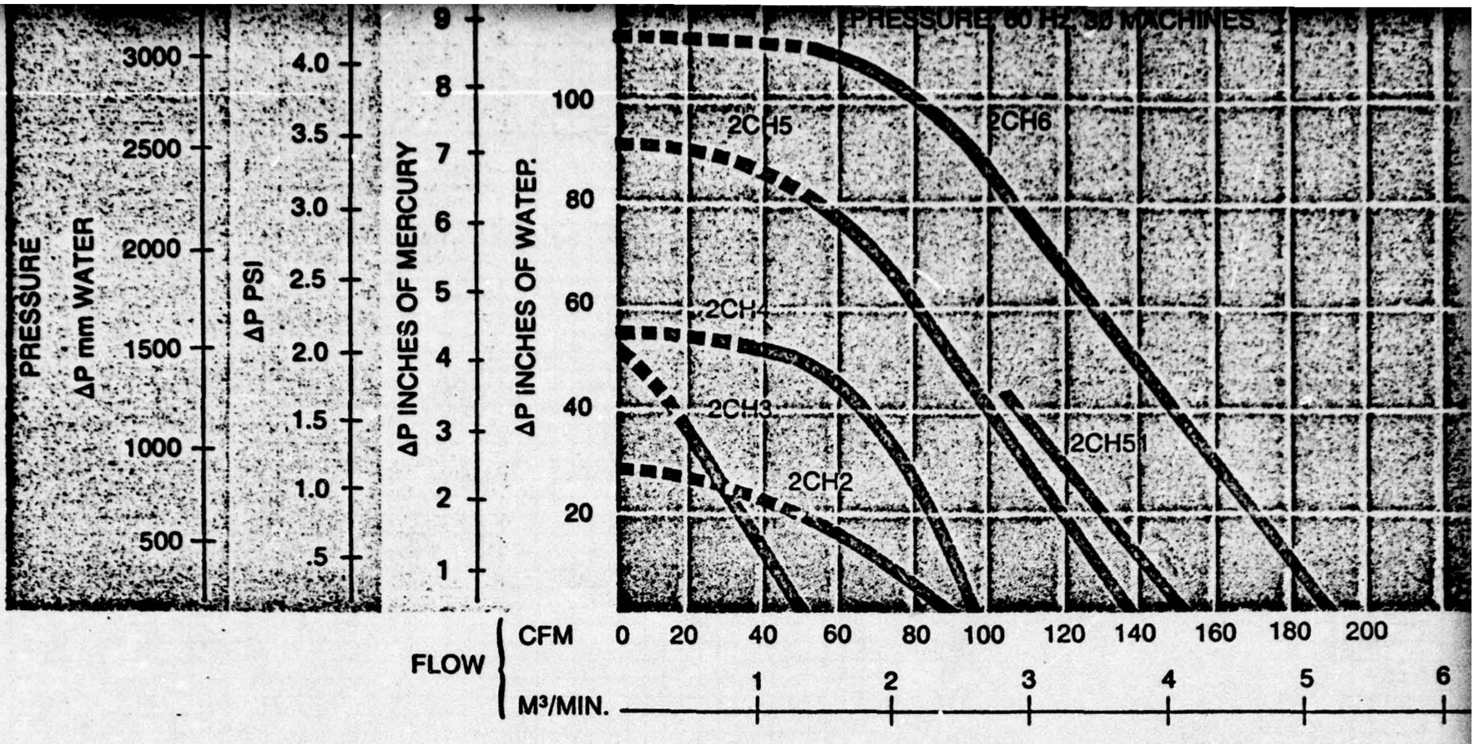

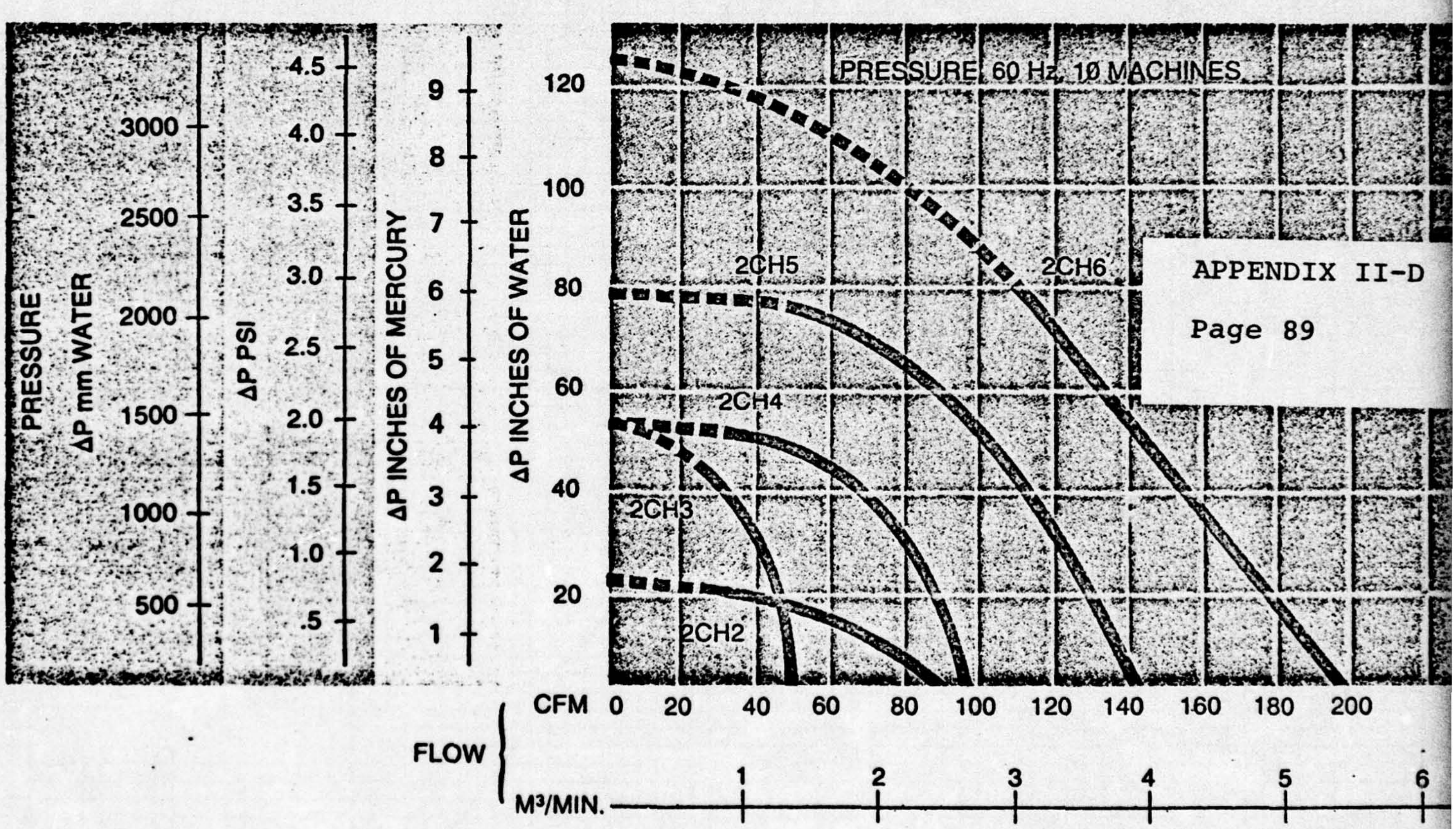

APPENDIX II-D

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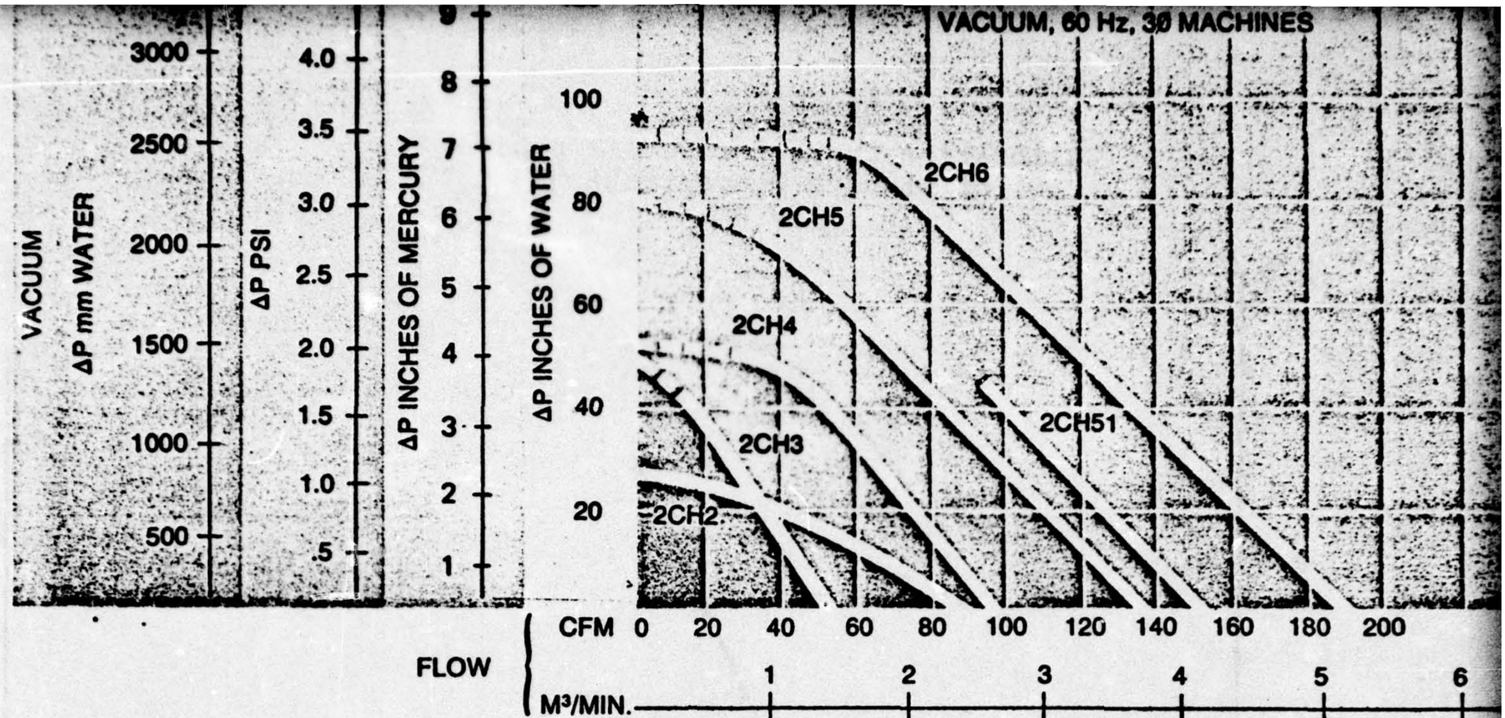
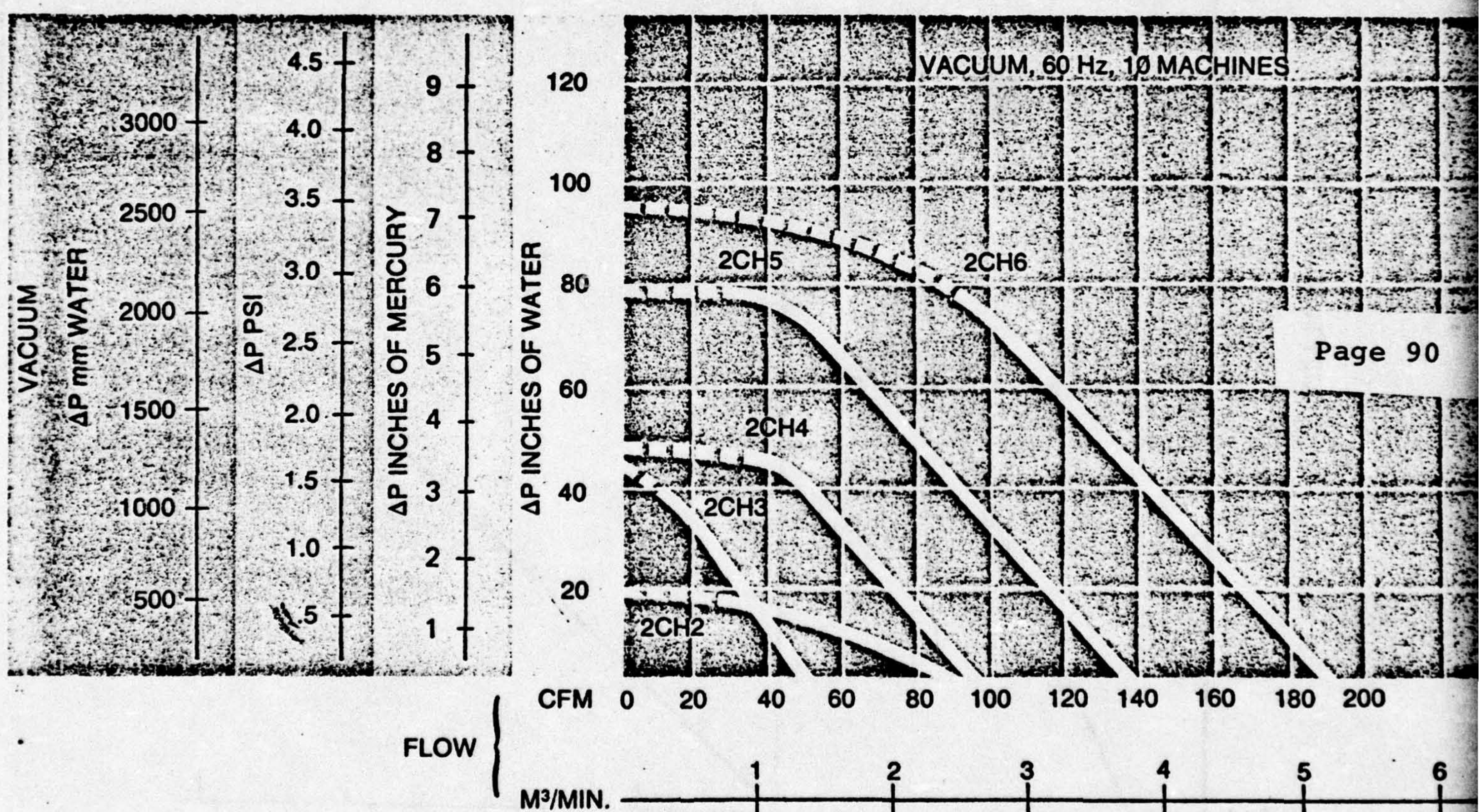
Comparative Performance

The performance of the various basic models of the Siemens Side Channel Compressors is shown on the curves. Performance curves for 50 Hz machines are available and will be supplied on request.

Note:
The values apply with a tolerance of ± 10% to a medium with a specific gravity of .0765 lbs./ft.³, referred to air at 15°C and intake conditions equaling 29.92" Hg.

All data refer to continuous duty performance measured after 30 minutes of running when temperatures have stabilized and *not* at start-up "cold" conditions when flow and pressure would be somewhat higher.





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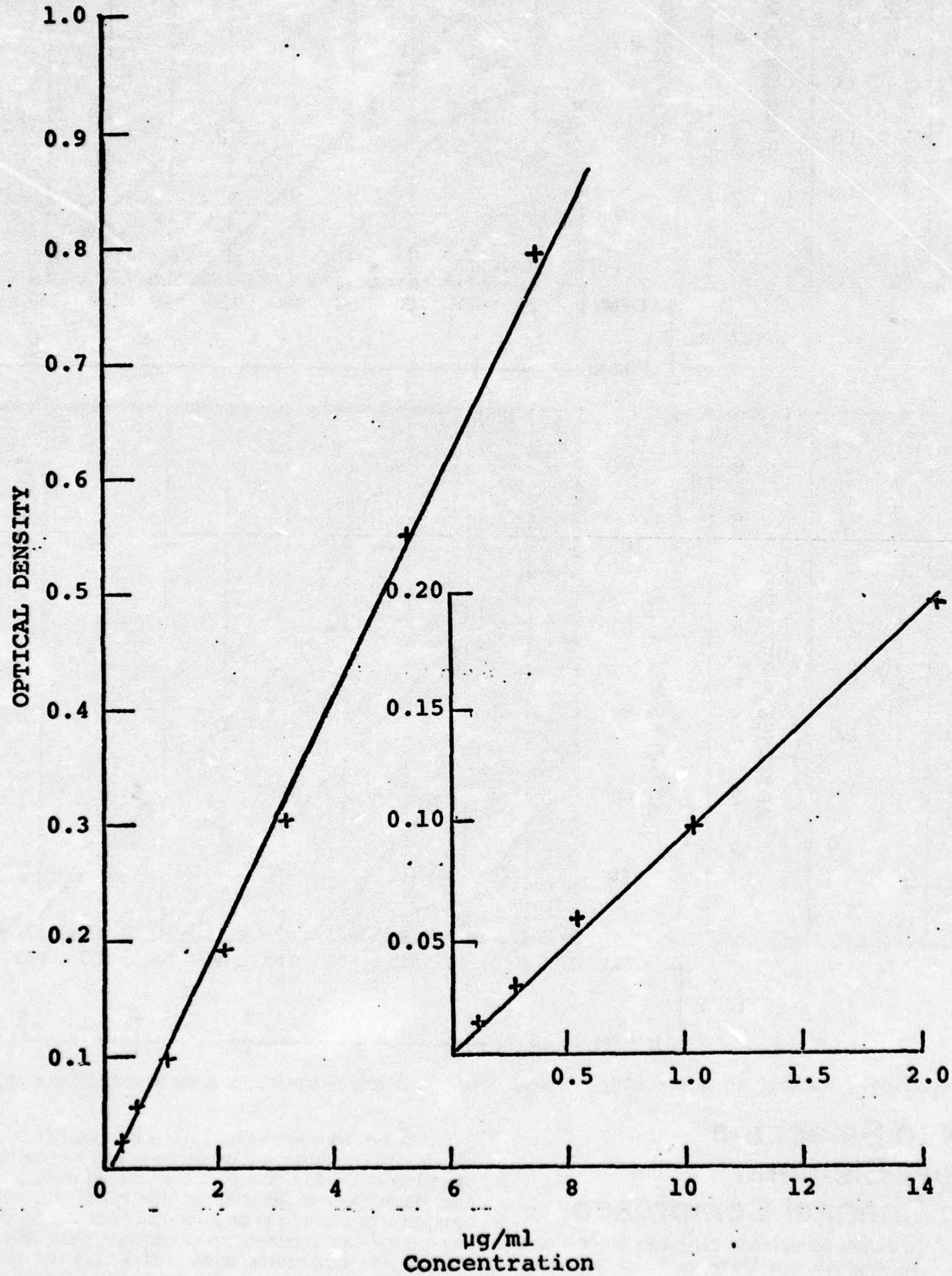
How to Select the Proper Siemens Side Channel Compressor

To select the proper compressor, determine from the performance curves which are likely to meet the requirements—making allowance for possible future increase if this is at all probable—and refer to the detailed specifications Tables on Pages 8 and 9 to select the optimum match.

Should the requirements fall outside the capabilities of the units whose performance is shown here, they may be met by using two or more units in parallel or staged or by a larger machine in Siemens 2BH8 series. The 2BH8 machines are compact units available in single or dual models. Dual models incorporate two impellers on a common shaft and dual shrouds. The compressor sections of a dual unit may be connected in parallel or in series at the user's option. A single unit 2BH8 machine may be converted to a dual unit by the addition of a second impeller housing assembly.

Appendix III

Calibration Curve for Determination of Uranine Concentration 190 nm.



APPENDIX IV

DETAILED DATA FOR CALIBRATION RUNS

Run: M1	Port	Concentration mg/m^3
Wright Dust Feed	1	14.33
Min-U-Sil 15 Packed to a	2	14.20
pressure of 1.5 tons for 1.0	3	14.03
minutes	4	14.34
0.019 m^3/s	5	13.52
multiport sampler inside chamber	6	14.09
66 minute sampling time	7	13.74
$\bar{X} = 14.06 \pm .29$ mg/m^3	8	14.22

Run: M2	Port	Concentration mg/m^3
Fluidizing Dust Generator	1	30.60
75.0 gms. Min-U-Sil 15	2	31.40
0.019 m^3/s	3	30.65
multiport sampler inside chamber	4	30.97
55 minute sampling	5	30.61
$\bar{X} = 30.82 \pm .41$ mg/m^3	6	30.54
	7	30.34
	8	31.43

Run: M3	Port	Concentration mg/m³
Fluidizing Dust Generator	1	49.58
75.0 gms Min-U-Sil 15	2	55.84
0.019 m^3/s	3	54.33
multiport sampler inside chamber	4	56.53
20 minute sampling	5	49.76
	6	54.33
$\overline{X} = 52.78 \pm 3.85$ mg/m^3	7	45.98
	8	55.90

Run: M4		
Fluidizing Generator	1	17.47
50.0 gms. Min-U-Sil 15	2	-----
0.019 m^3/s	3	17.84
	4	17.67
$\overline{X} = 18.14 \pm .68$ mg/m^3	5	18.98
	6	-----
	7	18.76
	8	18.18

Run: M5	Port	Concentration mg/m3
Fluidizing Generator	1	13.51
75.0 gms. Min-U-Sil 15	2	14.14
0.019 m^3/s	3	13.65
25 minute sampling	4	13.53
	5	13.82
$\overline{X} = 13.66 \pm .25$ mg/m^3	6	13.52
	7	13.44
	8	----
	T1	12.47
	T2	12.29
$\overline{X}_T = 12.29 \pm .18$ mg/m^3	T3	12.11

Run: M6	Port	Concentration mg/m3
Fluidizing Generator	1	7.08
75.0 gms Attacote	2	7.23
0.022 m^3/s	3	7.04
60 minute sampling	4	7.07
	5	7.26
$\overline{X} = 7.13 \pm .09$ mg/m^3	6	7.15
	7	7.05
	8	----
	T1	6.88
	T2	6.59
$\overline{X}_T = 6.67 \pm .19$ mg/m^3	T3	6.53

Run: M7	Port	Concentration mg/m^3
Ultrasonic Nebulizer	1	10.56
80 ml 3.5% uranine	2	11.16
0.022 m^3/s	3	-----
Spectrophotometric Determination	4	7.18
$\overline{X}$ = 9.35 $\pm$ 1.68 mg/m^3	5	9.99
$\overline{X}_T$ = 12.50 $\pm$ 1.17 mg/m^3	6	-----
	7	7.36
	8	9.82
	T1	11.17
	T2	13.34
	T3	12.99

Run: M8	Port	Weight mg/m^3	Spectro. mg/m^3
Ultrasonic Nebulizer	1	3.40	3.25
80 ml 7% uranine	3	3.42	2.96
0.020 m^3/s	5	3.46	3.46
	7	3.49	3.13
Spectrophotometric Determination	T1	3.42	3.28
$\overline{X}$ = 3.20 $\pm$ 0.21 mg/m^3	T2	3.73	3.48
$\overline{X}_T$ = 3.27 $\pm$ 0.21 mg/m^3	T3	3.57	3.35
Weight Determination	T4	3.68	2.98
$\overline{X}$ = 3.44 $\pm$ 0.04 mg/m^3			
$\overline{X}_T$ = 3.60 $\pm$ 0.14 mg/m^3			

Run: M9	Port	Concentration mg/m³
Ultrasonic Nebulizer	1	17.97
80 ml 1.75% uranine	3	17.57
$0.016\ m^3/s$	5	17.27
	7	16.92
Spectrophotometric Determination	T1	16.78
$\bar{X} = 15.95 \pm 0.44\ mg/m^3$	T2	17.06
$\bar{X}_T = 15.52 \pm 0.26\ mg/m^3$	T3	16.74
Weight Determination	T4	16.63
$\bar{X} = 17.43 \pm 0.45\ mg/m^3$		
$\bar{X}_T = 16.80 \pm 0.18\ mg/m^3$		

Run: N1	Port	Concentration mg/m³
$0.020\ m^3/s$	1	6.51
$\bar{X} = 6.57 \pm 0.13\ mg/m^3$	2	6.76
$\bar{X}_T = 6.23 \pm 0.10\ mg/m^3$	3	6.46
	4	6.52
	5	6.55
	6	6.75
	7	6.42
	8	6.61
	T1	6.33
	T2	6.14
	T3	6.21

Run: N2

0.020 m^3/s

Spiral Filter Settings

23 minute sampling

$\overline{X} = 6.50 \pm 0.09$ mg/m^3

$\overline{X}_T = 6.35 \pm 0.11$ mg/m^3

Port	Concentration mg/m^3
1	6.49
2	6.41
3	6.56
4	6.51
5	6.38
6	6.62
7	6.40
8	6.60
T1	6.47
T2	6.27
T3	6.31

Run: N3

0.024 m^3/s

$\overline{X} = 4.90 \pm 0.13$ mg/m^3

$\overline{X}_T = 4.78 \pm 0.12$ mg/m^3

Port	Concentration mg/m^3
1	4.95
2	5.01
3	4.79
4	4.80
5	4.71
6	5.10
7	4.94
8	4.86
T1	4.86
T2	4.64
T3	4.83

Run: N4	Port	Concentration mg/m^3
$0.016\ m^3/s$	1	8.16
25 minute sampling	2	8.44
$\bar{X} = 8.12 \pm 0.14\ mg/m^3$	3	8.07
$\bar{X}_T = 7.67 \pm 0.21\ mg/m^3$	4	8.09
	5	8.10
	6	8.03
	7	7.95
	8	8.15
	T1	7.91
	T2	7.54
	T3	7.52

Run: N5	Port	Concentration mg/m^3
$0.012\ m^3/s$	1	9.94
$\bar{X} = 10.07 \pm 0.31\ mg/m^3$	2	9.95
$\bar{X}_T = 9.61 \pm 0.20\ mg/m^3$	3	9.76
	4	9.91
	5	9.98
	6	10.22
	7	10.78
	8	10.01
	T1	9.67
	T2	9.38
	T3	9.77

Run: W1

0.012 m^3/s

Gear ratio, 1 to 1.5

$\bar{X} = 70.04 \pm 0.73$ mg/m^3

$\bar{X}_T = 67.41 \pm 1.30$ mg/m^3

Port	Concentration mg/m^3
1	-
2	70.57
3	69.74
4	69.90
5	70.45
6	70.54
7	68.58
8	70.53
T1	68.55
T2	65.99
T3	67.70

Run: W2

0.012 m^3/s

$\bar{X} = 9.88 \pm 0.14$ mg/m^3

$\bar{X}_T = 9.34 \pm 0.19$ mg/m^3

Port	Concentration mg/m^3
1	9.87
2	9.69
3	9.84
4	----
5	9.78
6	10.08
7	10.01
8	9.82
T1	9.47
T2	9.20
T3	----

Run: W3	Port	Concentration mg/m^3
$0.016\ m^3/s$	1	5.12
$\overline{X} = 5.07 \pm 0.05\ mg/m^3$	2	----
$\overline{X}_T = 4.93 \pm 0.07\ mg/m^3$	3	5.04
	4	5.03
	5	5.07
	6	5.14
	7	5.08
	8	4.98
	T1	5.00
	T2	4.93
	T3	4.86

Run: W4	Port	Concentration mg/m^3
$0.024\ m^3/s$	1	3.95
$\overline{X} = 3.88 \pm 0.12\ mg/m^3$	2	4.04
$\overline{X}_T = 3.75 \pm 0.10\ mg/m^3$	3	3.87
	4	3.81
	5	4.00
	6	3.74
	7	3.90
	8	3.72
	T1	3.87
	T2	3.68
	T3	3.70

Run: W5	Port	Concentration mg/m^3
$0.020\ m^3/s$	1	18.93
Spiral filter settings	2	19.25
$\bar{X} = 19.58 \pm 0.94\ mg/m^3$	3	19.09
$\bar{X}_T = 18.49 \pm 0.31\ mg/m^3$	4	18.75
	5	19.66
	6	21.40
	7	20.58
	8	18.96
	T1	18.97
	T2	18.14
	T3	18.35
$\bar{X}_C = 10.05 \pm 0.96\ mg/m^3$	Unico 240 Cyclones	
equivalent to 54% of total concentration	TA	9.02
	TB	11.16
	TC	9.51
	TD	10.49

Run: F1	Port	Concentration mg/m^3
$0.012\ m^3/s$	1	17.40
Spiral filter settings	2	17.36
$\overline{X} = 16.49 \pm 1.05\ mg/m^3$	3	17.40
$\overline{X}_T = 17.39 \pm 0.44\ mg/m^3$	4	16.52
	5	16.27
	6	15.93
	7	14.53
	8	-----
	T1	17.83
	T2	16.95
	T3	17.38

Run: F2	Port	Concentration mg/m^3
$0.016\ m^3/s$	1	12.13
$\overline{X} = 12.25 \pm 0.26\ mg/m^3$	2	12.48
$\overline{X}_T = 10.82 \pm 0.46\ mg/m^3$	3	12.43
	4	11.93
	5	12.28
	6	12.61
	7	12.29
	8	11.86
	T1	11.24
	T2	10.32
	T3	10.89

Run: F3	Port	Concentration mg/m^3
0.020 m^3/s	1	18.20
$\bar{X} = 18.21 \pm 0.35$ mg/m^3	2	18.20
$X_T = 16.64$ mg/m^3	3	17.74
	4	17.77
	5	18.67
	6	18.54
	7	18.34
	T2	16.64
Aerotec 3/4" cyclones	T1	6.87
	T3	6.15

$\bar{X} = 6.52$ mg/m^3 equivalent to 39% of total concentration

Unico 240 cyclones	TB	9.91
	TD	9.50

$\bar{X} = 9.71$ mg/m^3 equivalent to 58% of total concentration

Run: F4	Port	Concentration mg/m3
0.020 m^3/s	1	----
$\overline{X} = 17.32 \pm 0.46$ mg/m^3	2	17.22
$\overline{X}_T = 16.65 \pm 0.83$ mg/m^3	3	----
	4	16.67
	5	17.77
	6	17.76
	7	----
	8	17.20
	T1	17.30
	T2	16.94
	T3	15.72
Aerotec "3/4" cyclones	3	6.93
	7	7.01

$\overline{X}_C = 6.97$ mg/m^3, equivalent to 40% of total concentration

Unico 240 cyclones	TB	9.20
	TD	8.89

$\overline{X}_C = 9.05$ mg/m^3, equivalent to 54% of total concentration

Run: F5	Port	Concentration mg/m^3
$0.024\ m^3/s$	1	-----
$\overline{X} = 18.83 \pm 0.47\ mg/m^3$	2	19.18
$\overline{X}_T = 18.25 \pm 1.14\ mg/m^3$	3	-----
	4	18.46
	5	-----
	6	18.39
	7	-----
	8	19.30
	T1	19.26
	T2	18.46
	T3	17.02
Aerotec "3/4" cyclones	3	7.80
	7	8.92

$\overline{X} = 8.36\ mg/m^3$, equivalent to 44% of total concentration

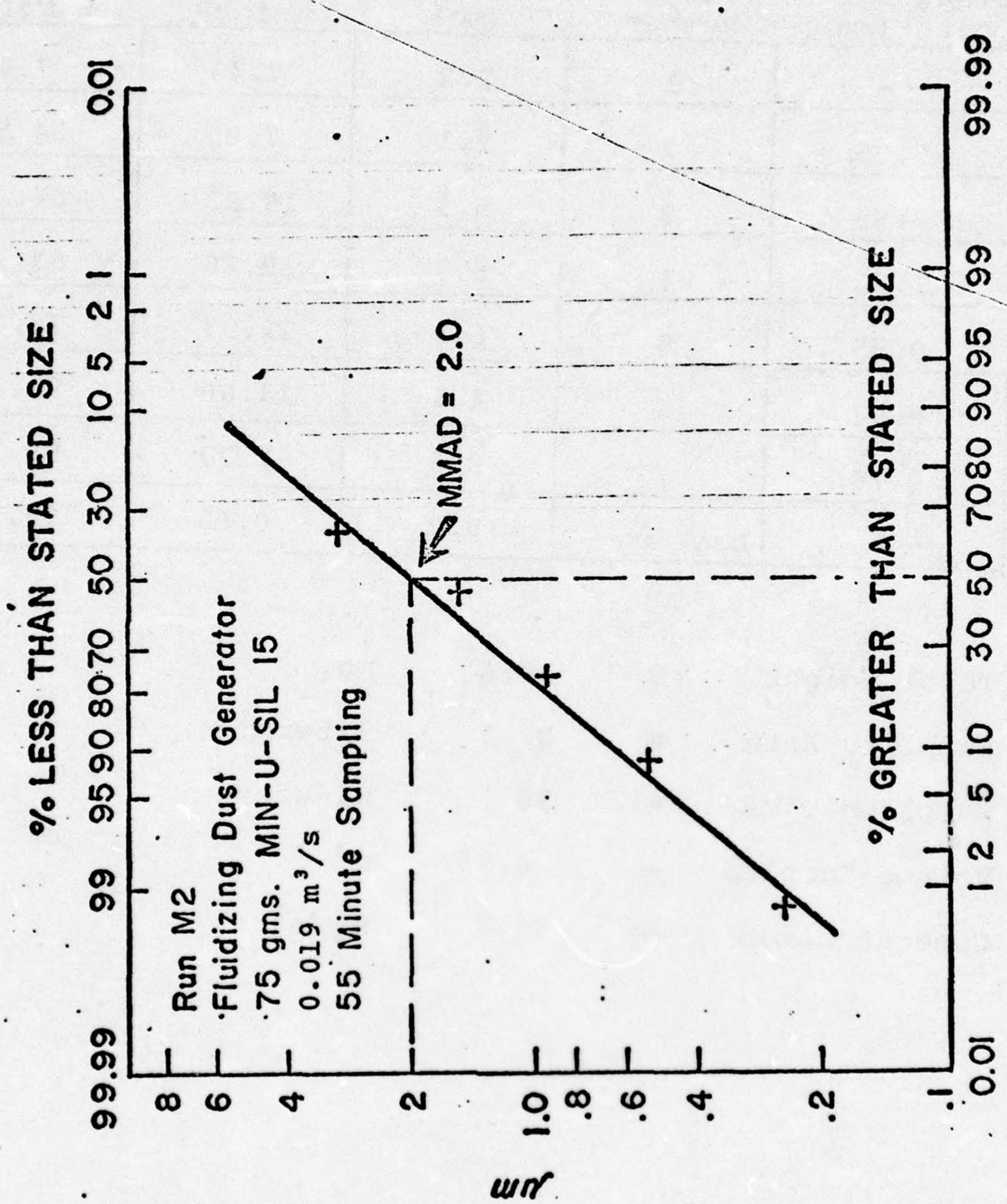
Unico 240 cyclones	TA	9.47
	TB	10.84
	TC	10.49
	TD	10.80

$\overline{X} = 10.40\ mg/m^3$, equivalent to 57% of total concentration

RUN M2 , Andersen Sampler

Stage 50% point (µm)	Stage Number	Weight (mg)	% Weight	Cumulative % Weight
---	1	2.2	7.43	7.43
5.35	2	2.1	7.09	14.52
2.95	3	5.9	19.93	34.45
1.53	4	5.7	19.26	53.71
0.95	5	6.8	22.97	76.68
0.54	6	4.4	14.86	91.54
0.24	7	2.3	7.77	99.31
----	back-up	0.2	0.68	99.99

Total Weight	=	29.6	mg
Sampling Rate	=	28.3	liter/min.
Sampling Time	=	30	minutes
Volume Sampled	=	0.85	m^3
Concentration	=	34.8	mg/m^3

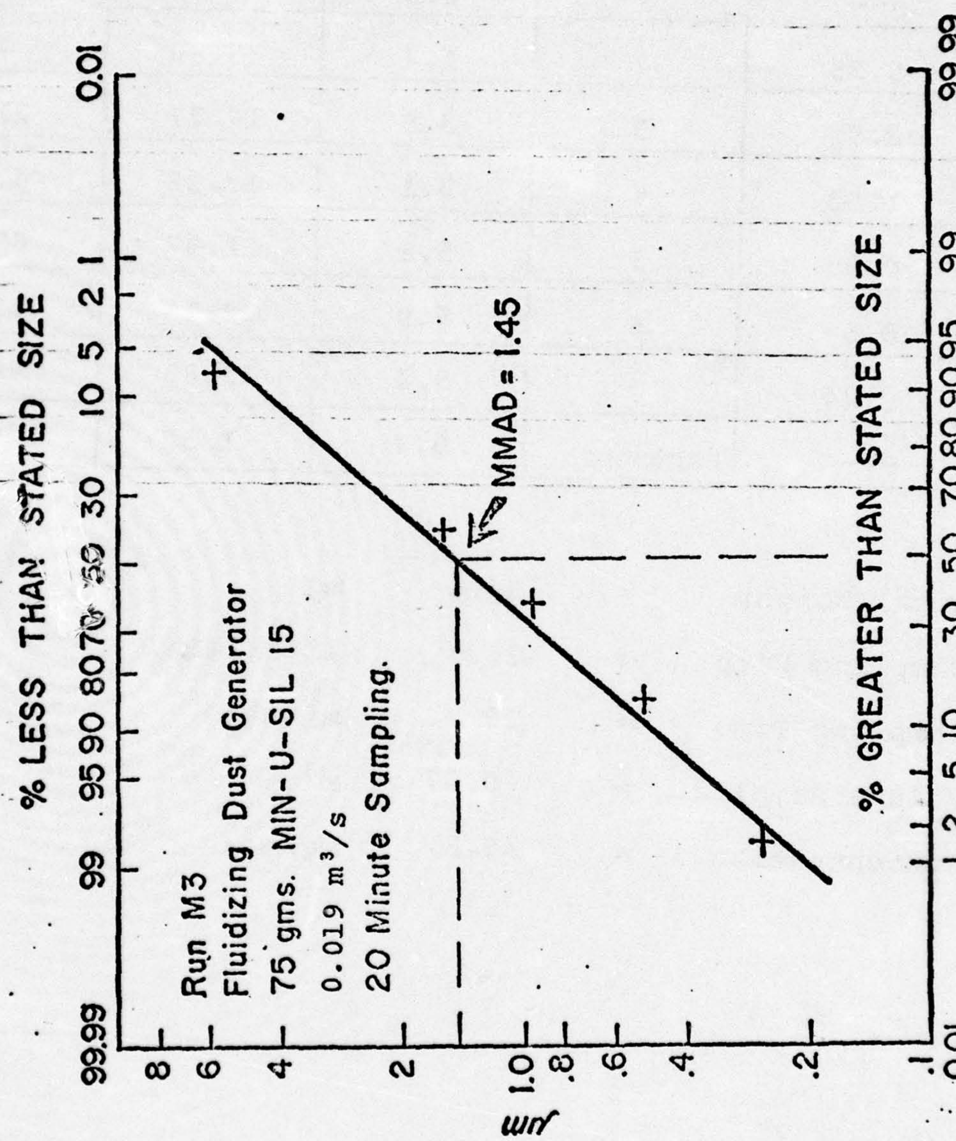


% LESS THAN STATED SIZE
% GREATER THAN STATED SIZE
99.99
99
95 90 80 70
50
30
10 5
2 1
0.01
99.99
99
95 90
70 80
50
30
10 5
2 1
0.01
Run M2
Fluidizing Dust Generator
75 gms. MIN-U-SIL 15
0.019 m³/s
55 Minute Sampling
MMAD = 2.0
8
6
4
2
1.0
.8
.6
.4
.2
.1
μm

RUN M3, Andersen Sampler

Stage 50% point (μm)	Stage Number	Weight (mg)	% Weight	Cumulative % Weight
---	1	0.5	1.89	1.89
5.35	2	1.4	5.30	7.19
2.95	3	3.9	14.77	21.96
1.53	4	5.1	19.32	41.28
0.95	5	5.8	21.97	63.25
0.54	6	5.9	22.35	85.60
0.24	7	3.4	12.88	98.48
---	back-up	0.4	1.52	100.00

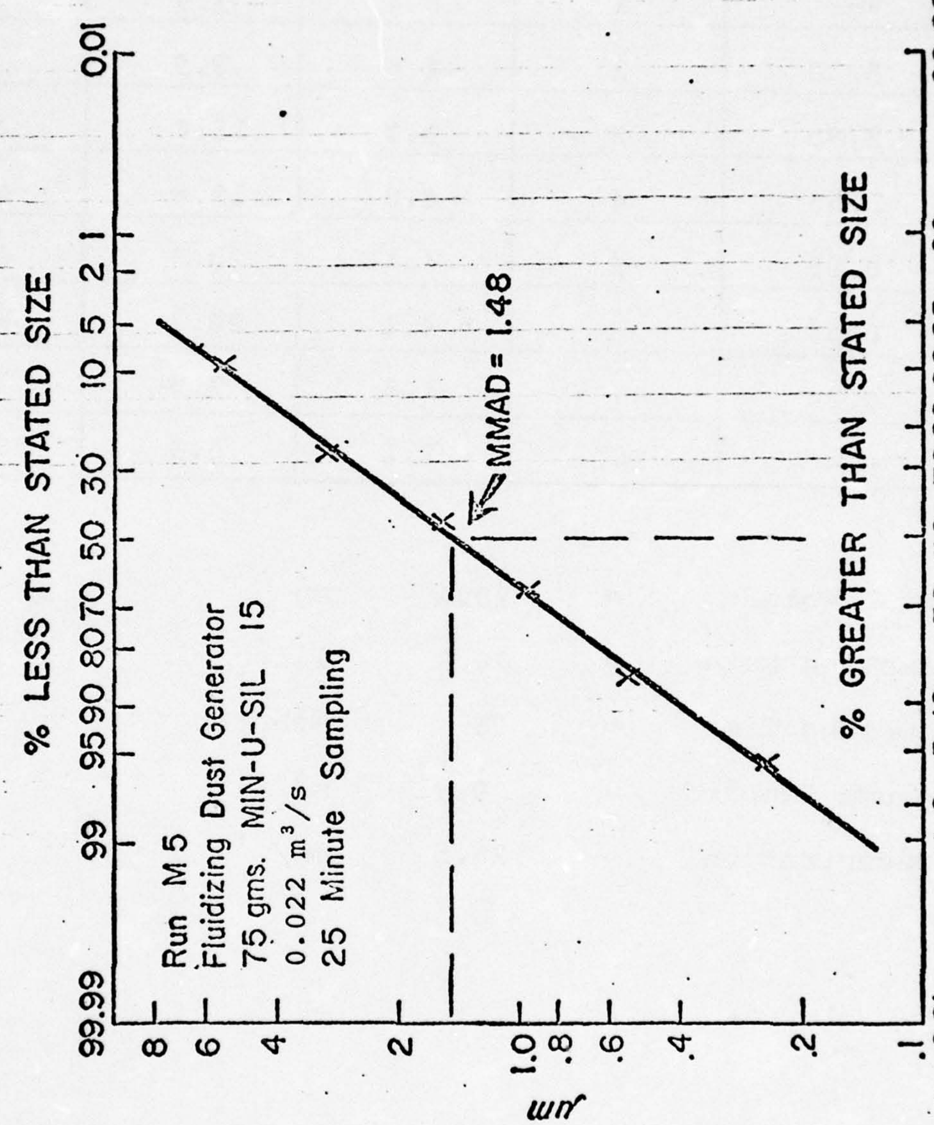
Total Weight	=	26.4	mg
Sampling Rate	=	28.3	liter/min.
Sampling Time	=	20	minutes
Volume Sampled	=	0.57	m^3
Concentration	=	46.3	mg/m^3


% LESS THAN STATED SIZE
99.99 99 95 90 80 70 50 30 10 5 2 1 0.01
Run M3
Fluidizing Dust Generator
75 gms. MIN-U-SIL 15
0.019 m³/s
20 Minute Sampling.
MMAD = 1.45
μm
8 6 4 2 1.0 .8 .6 .4 .2 .1
% GREATER THAN STATED SIZE
0.01 1 2 5 10 30 50 70 80 90 95 99 99.99

RUN M5, Andersen Sampler

Stage 50% point (μm)	Stage Number	Weight (mg)	% Weight	Cumulative % Weight
---	1	0.4	1.9	1.9
5.35	2	1.6	7.9	9.8
2.95	3	3.2	15.8	25.6
1.53	4	4.0	19.8	45.4
0.95	5	4.1	20.3	65.7
0.54	6	4.1	20.3	86.0
0.24	7	1.6	7.9	93.9
---	back-up	1.2	5.9	99.8

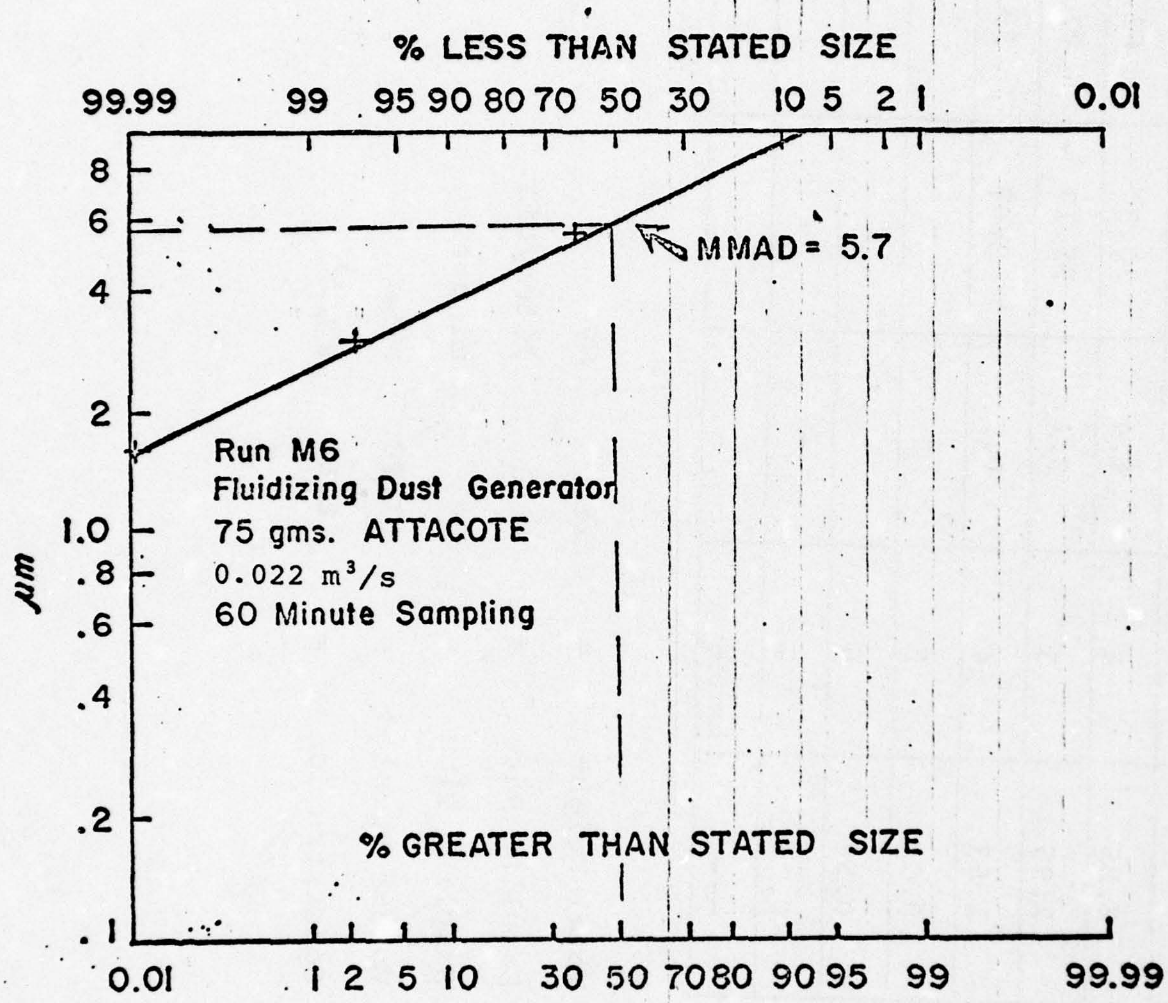
Total Weight	=	20.2	mg
Sampling Rate	=	28.3	liter/min.
Sampling Time	=	25	minutes
Volume Sampled	=	0.71	m^3
Concentration	=	28.5	mg/m^3


% LESS THAN STATED SIZE
99.99 99 95 90 80 70 50 30 10 5 2 1 0.01
% GREATER THAN STATED SIZE
0.01 1 2 5 10 30 50 70 80 90 95 99 99.99
MMAD = 1.48
Run M5
Fluidizing Dust Generator
75 gms. MIN-U-SIL 15
0.022 m^3/s
25 Minute Sampling
μm
8 6 4 2 1.0 .8 .6 .4 .2 .1

RUN M6, Andersen Sampler

Stage 50% point (μm)	Stage Number	Weight (mg)	% Weight	Cumulative % Weight
---	1	4.7	32.41	32.41
5.35	2	4.4	30.34	62.75
2.95	3	5.1	35.17	97.92
1.53	4	0.3	2.07	99.99
0.95	5	-	-	-
0.54	6	-	-	-
0.24	7	-	-	-
---	back-up	-	-	-

Total Weight	=	14.5	mg
Sampling Rate	=	28.3	liter/min.
Sampling Time	=	60	minutes
Volume Sampled	=	1.70	m^3
Concentration	=	8.53	mg/m^3


% LESS THAN STATED SIZE
99.99 99 95 90 80 70 50 30 10 5 2 1 0.01
8
6
4
2
1.0
.8
.6
.4
.2
.1
μm
MMAD= 5.7
Run M6
Fluidizing Dust Generator
75 gms. ATTACOTE
0.022 m³/s
60 Minute Sampling
% GREATER THAN STATED SIZE
0.01 1 2 5 10 30 50 70 80 90 95 99 99.99

RUN M7

Andersen Sampler,
Spectrophotometric Determination

Stage 50% point (µm)	Stage Number	Weight (mg)	% Weight	Cumulative % Weight
---	1	0.0125	0.23	0.23
5.35	2	0.0245	0.46	0.69
2.95	3	0.145	2.73	3.42
1.53	4	2.250	42.33	45.75
0.95	5	2.580	48.53	94.28
0.54	6	0.247	4.65	98.93
0.24	7	0.0285	0.53	99.46
---	back-up	0.0285	0.53	99.99

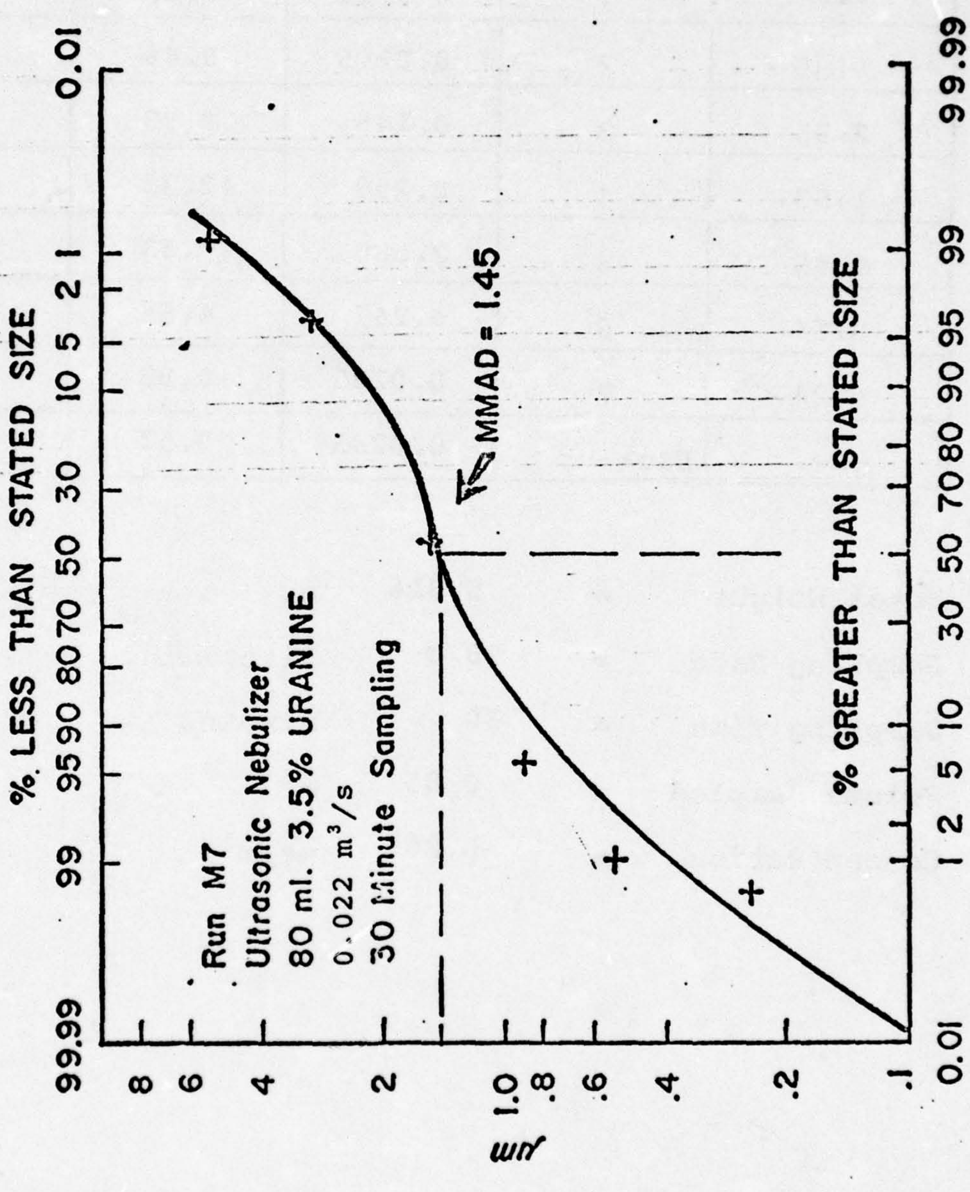
Total Weight = 5.316 mg

Sampling Rate = 28.3 liter/min.

Sampling Time = 30 minutes

Volume Sampled = 0.85 m^3

Concentration = 6.26 mg/m^3

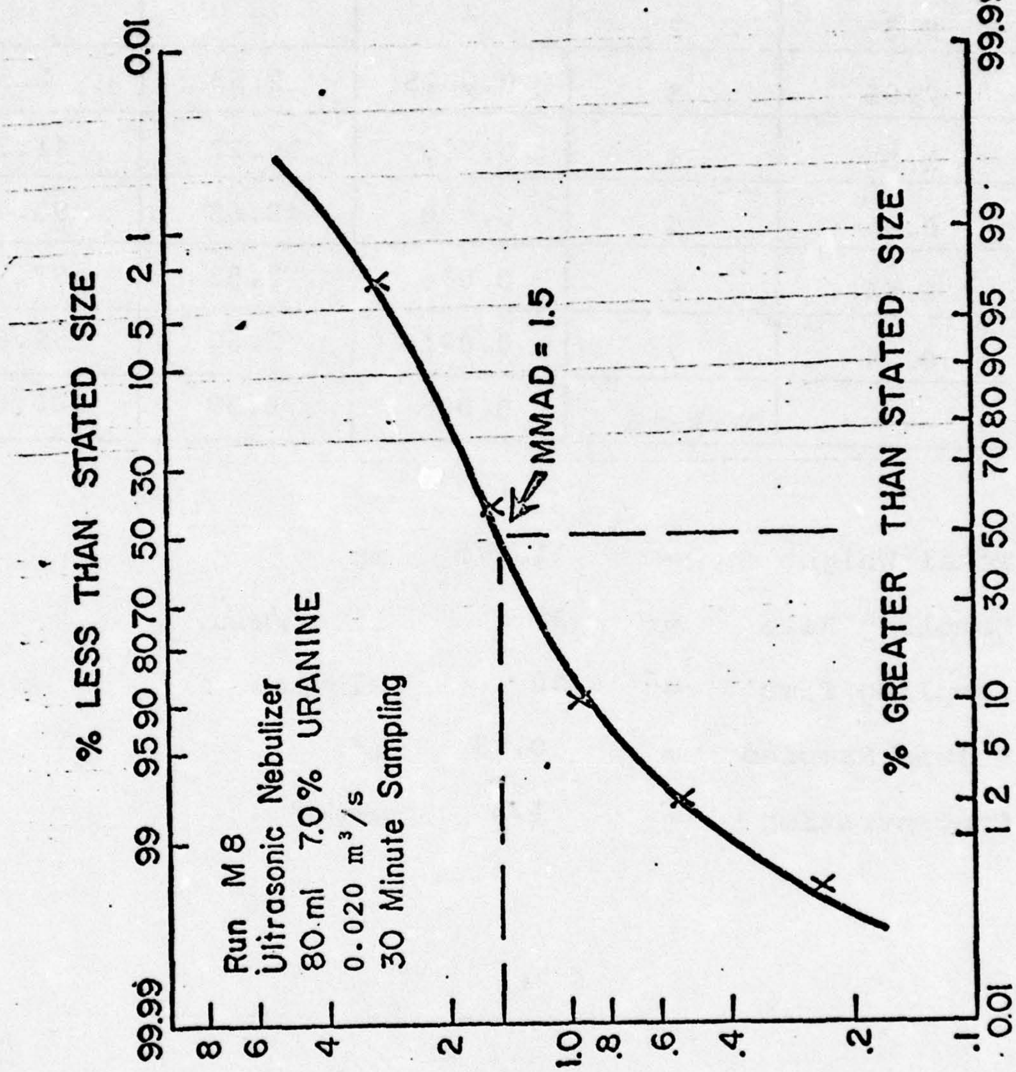


% LESS THAN STATED SIZE
99.99
99
95 90 80 70 50
30
10 5 2 1
0.01
% GREATER THAN STATED SIZE
0.01
1 2 5 10 30 50 70 80 90 95
99
99.99
μm
8
6
4
2
1.0
.8
.6
.4
.2
.1
Run M7
Ultrasonic Nebulizer
80 ml. 3.5% URANINE
0.022 m³/s
30 Minute Sampling
MMAD = 1.45

RUN M8 Andersen Sampler

Stage 50% point (μm)	Stage Number	Weight (mg)	% Weight	Cumulative % Weight
---	1	-	-	-
5.35	2	-	-	-
2.95	3	0.0325	2.55	2.55
1.53	4	0.500	39.22	41.77
0.95	5	0.620	48.63	90.40
0.54	6	0.096	7.53	97.93
0.24	7	0.0215	1.69	99.62
---	back-up	0.005	0.39	100.01

Total Weight	=	1.275	mg
Sampling Rate	=	28.3	liter/min.
Sampling Time	=	30	minutes
Volume Sampled	=	0.85	m^3
Concentration	=	1.5	mg/m^3


% LESS THAN STATED SIZE
% GREATER THAN STATED SIZE
MMAD = 1.5
Run M8
Ultrasonic Nebulizer
80 ml 7.0% URANINE
0.020 m³/s
30 Minute Sampling
μm

Andersen Sampler,
Spectrophotometric Determination

RUN M9

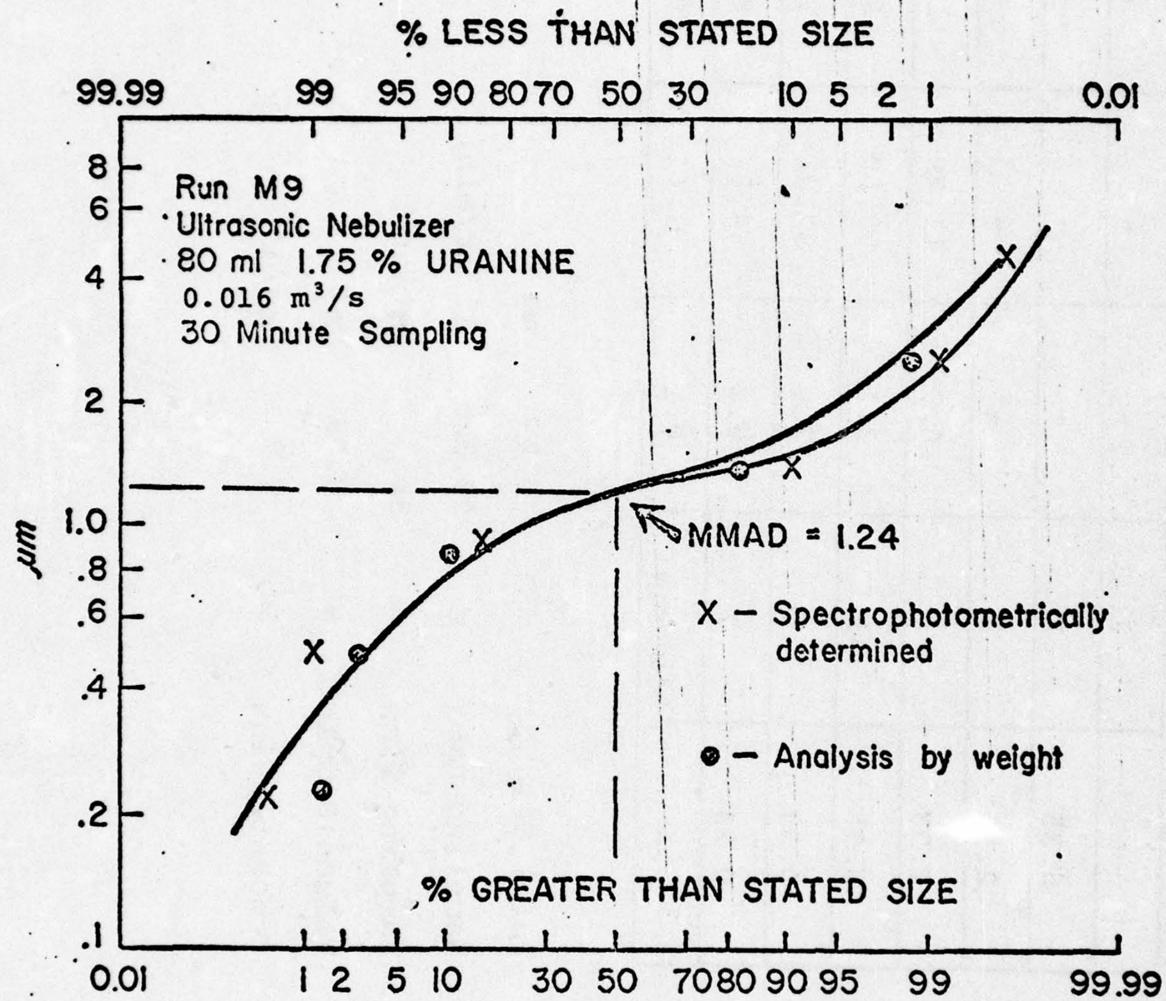
Stage 50% point (μm)	Stage Number	Weight (mg)	% Weight	Cumulative % Weight
---	1	0.004	0.06	0.06
5.35	2	0.007	0.10	0.16
2.95	3	0.038	0.53	0.69
1.53	4	0.600	8.33	9.02
0.95	5	5.600	77.78	86.80
0.54	6	0.875	12.15	98.95
0.24	7	0.035	0.49	99.44
---	back-up	0.039	0.55	99.99

Total Weight	=	7.198	mg
Sampling Rate	=	28.3	liter/min.
Sampling Time	=	30	minutes
Volume Sampled	=	0.85	m^3
Concentration	=	8.46	mg/m^3

RUN M9 Weight Determination, Andersen Sampler

Stage 50% point (μm)	Stage Number	Weight (mg)	% Weight	Cumulative % Weight
---	1	-	-	-
5.35	2	-	-	-
2.95	3	0.1	1.33	1.33
1.53	4	1.2	16.00	17.33
0.95	5	5.5	73.33	90.67
0.54	6	0.5	6.66	97.33
0.24	7	0.1	1.33	98.66
---	back-up	0.1	1.33	99.99

Total Weight	=	7.5	mg
Sampling Rate	=	28.3	liter/min.
Sampling Time	=	30	minutes
Volume Sampled	=	0.85	m^3
Concentration	=	8.84	mg/m^3


% LESS THAN STATED SIZE
99.99
99
95
90
80
70
50
30
10
5
2
1
0.01
Run M9
Ultrasonic Nebulizer
80 ml 1.75 % URANINE
0.016 m³/s
30 Minute Sampling
8
6
4
2
1.0
.8
.6
.4
.2
.1
μm
MMAD = 1.24
X – Spectrophotometrically determined
– Analysis by weight
% GREATER THAN STATED SIZE
0.01
1
2
5
10
30
50
70
80
90
95
99
99.99

RUN N1

Andersen Sampler
WEIGHT DETERMINATION, LOWER PORT

Stage 50% point (μm)	Stage Number	Weight (mg)	% Weight	Cumulative % Weight
---	1	-	-	-
5.35	2	-	-	-
2.95	3	-	-	-
1.53	4	0.7	11.29	11.29
0.95	5	3.1	50.00	61.29
0.54	6	2.0	32.26	93.55
0.24	7	0.3	4.84	98.39
---	back-up	0.1	1.61	100.00

Total Weight = 6.2 mg

Sampling Rate = 28.3 liter/min.

Sampling Time = 30 minutes

Volume Sampled = 0.85 m^3

Concentration = 7.3 mg/m^3

RUN N1 — Andersen Sampler
Weight Determination, Upper Port

Stage 50% point (μm)	Stage Number	Weight (mg)	% Weight	Cumulative % Weight
---	1	-	-	-
5.35	2	-	-	-
2.95	3	-	-	-
1.53	4	0.6	8.70	8.70
0.95	5	4.2	60.87	69.57
0.54	6	1.6	23.19	92.76
0.24	7	0.4	5.80	98.56
---	back-up	0.1	1.45	100.01

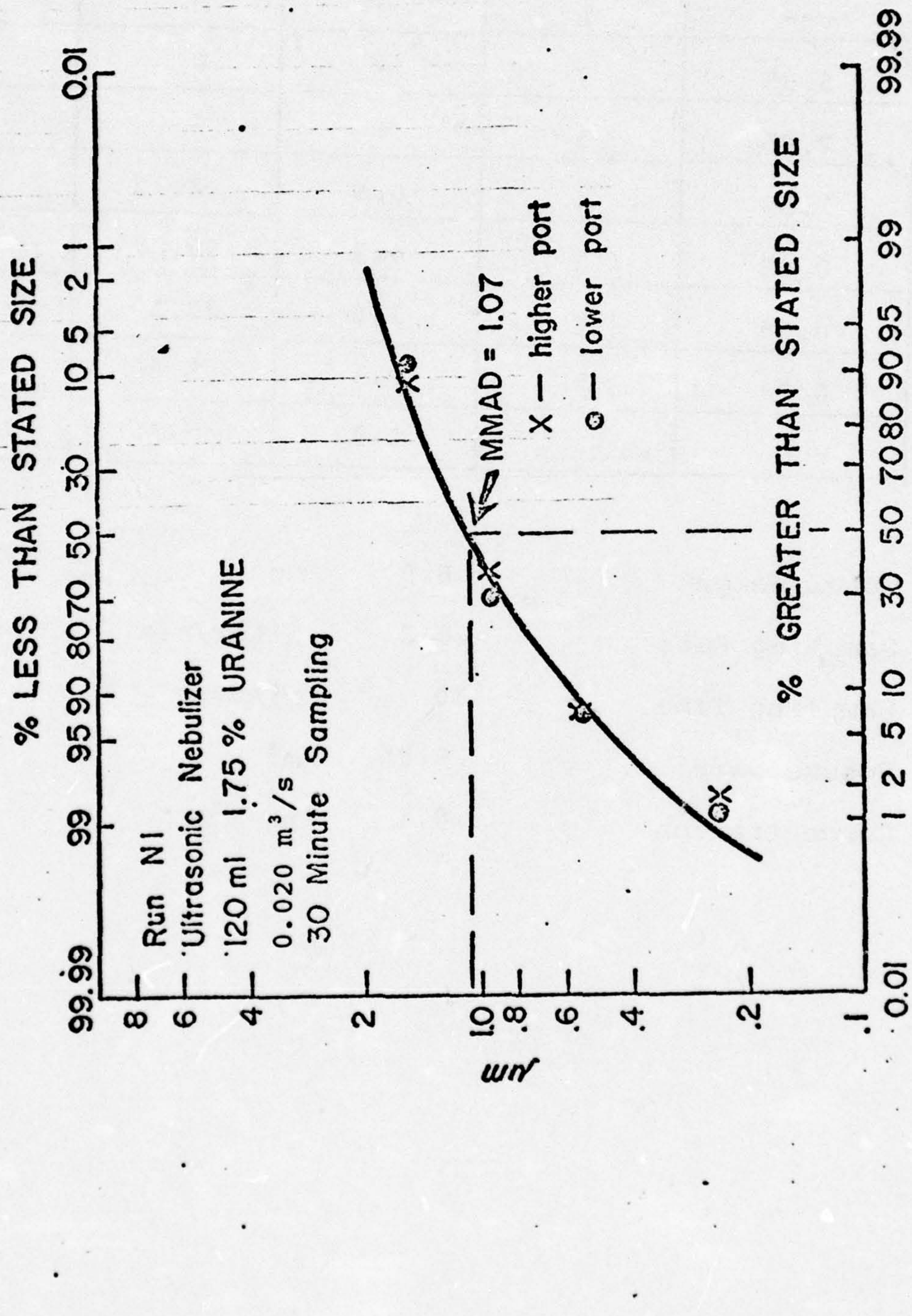
Total Weight = 6.9 mg

Sampling Rate = 28.3 liter/min.

Sampling Time = 30 minutes

Volume Sampled = 0.85 m^3

Concentration = 8.1 mg/m^3


% LESS THAN STATED SIZE
99.99 99 95 90 80 70 50 30 10 5 2 1 0.01
Run N1
Ultrasonic Nebulizer
120 ml 1.75 % URANINE
0.020 m³/s
30 Minute Sampling
MMAD = 1.07
X — higher port
⊙ — lower port
μm
8 6 4 2 1.0 .8 .6 .4 .2 .1
% GREATER THAN STATED SIZE
0.01 1 2 5 10 30 50 70 80 90 95 99 99.99

RUN N2 Weight Determination, Andersen Sampler

Stage 50% point (μm)	Stage Number	Weight (mg)	% Weight	Cumulative % Weight
---	1	-	-	-
5.35	2	-	-	-
2.95	3	0.1	1.72	1.72
1.53	4	0.3	5.17	6.89
0.95	5	2.6	44.83	51.72
0.54	6	1.8	31.03	82.75
0.24	7	0.9	15.52	98.27
---	back-up	0.1	1.72	99.99

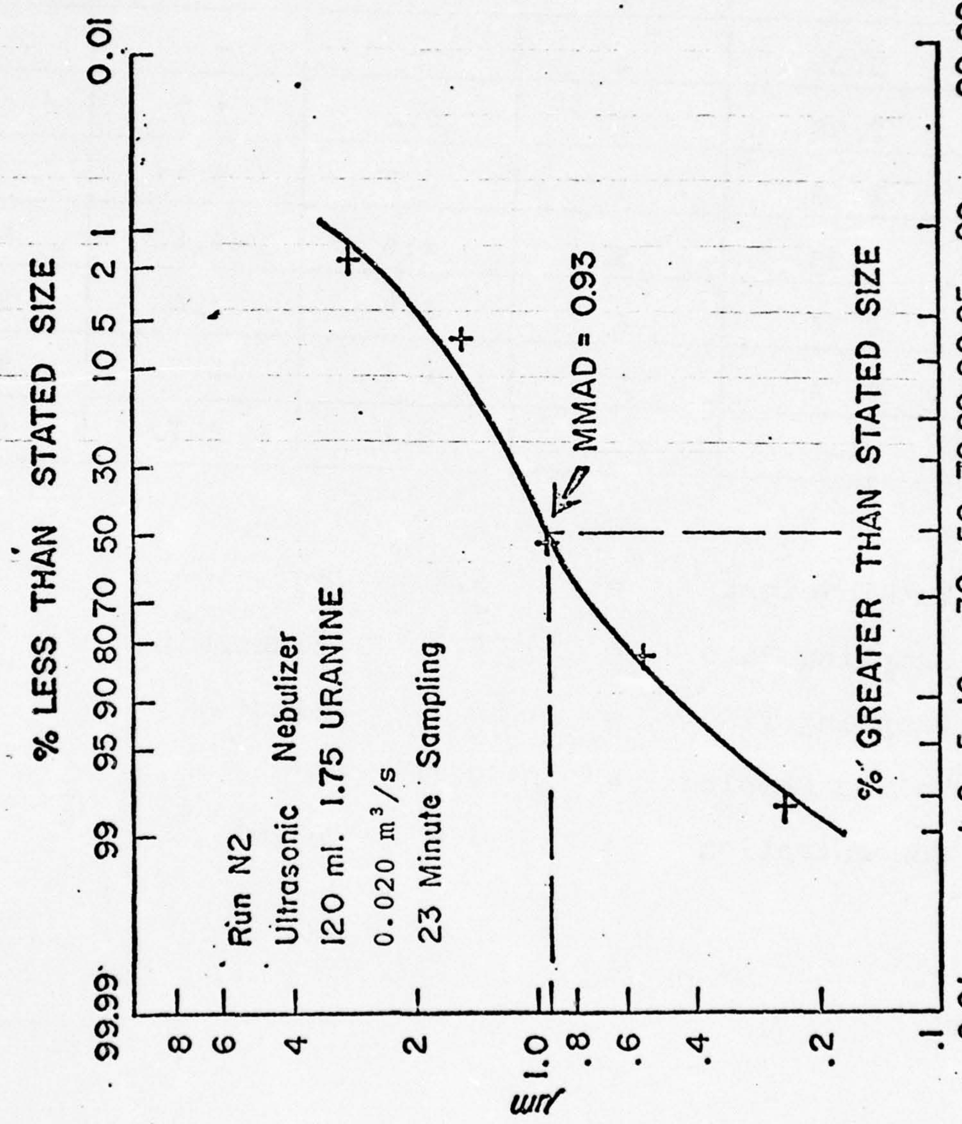
Total Weight = 5.8 mg

Sampling Rate = 28.3 liter/min.

Sampling Time = 30 minutes

Volume Sampled = 0.85 m^3

Concentration = 6.8 mg/m^3


% LESS THAN STATED SIZE
99.99 99 95 90 80 70 50 30 10 5 2 1 0.01
% GREATER THAN STATED SIZE
0.01 1 2 5 10 30 50 70 80 90 95 99 99.99
MMAD = 0.93
Run N2
Ultrasonic Nebulizer
120 ml. 1.75 URANINE
0.020 m^3/s
23 Minute Sampling
8 6 4 2 1.0 .8 .6 .4 .2 .1
μm

RUN N3

Andersen Sampler
Spectrophotometric Determination

Stage 50% point (μm)	Stage Number	Weight (mg)	% Weight	Cumulative % Weight
---	1	-	-	-
5.35	2	-	-	-
2.95	3	-	-	-
1.53	4	0.005	0.39	0.39
0.95	5	0.70	54.22	54.61
0.54	6	0.53	41.05	95.66
0.24	7	0.046	3.56	99.22
---	back-up	0.010	0.78	100.00

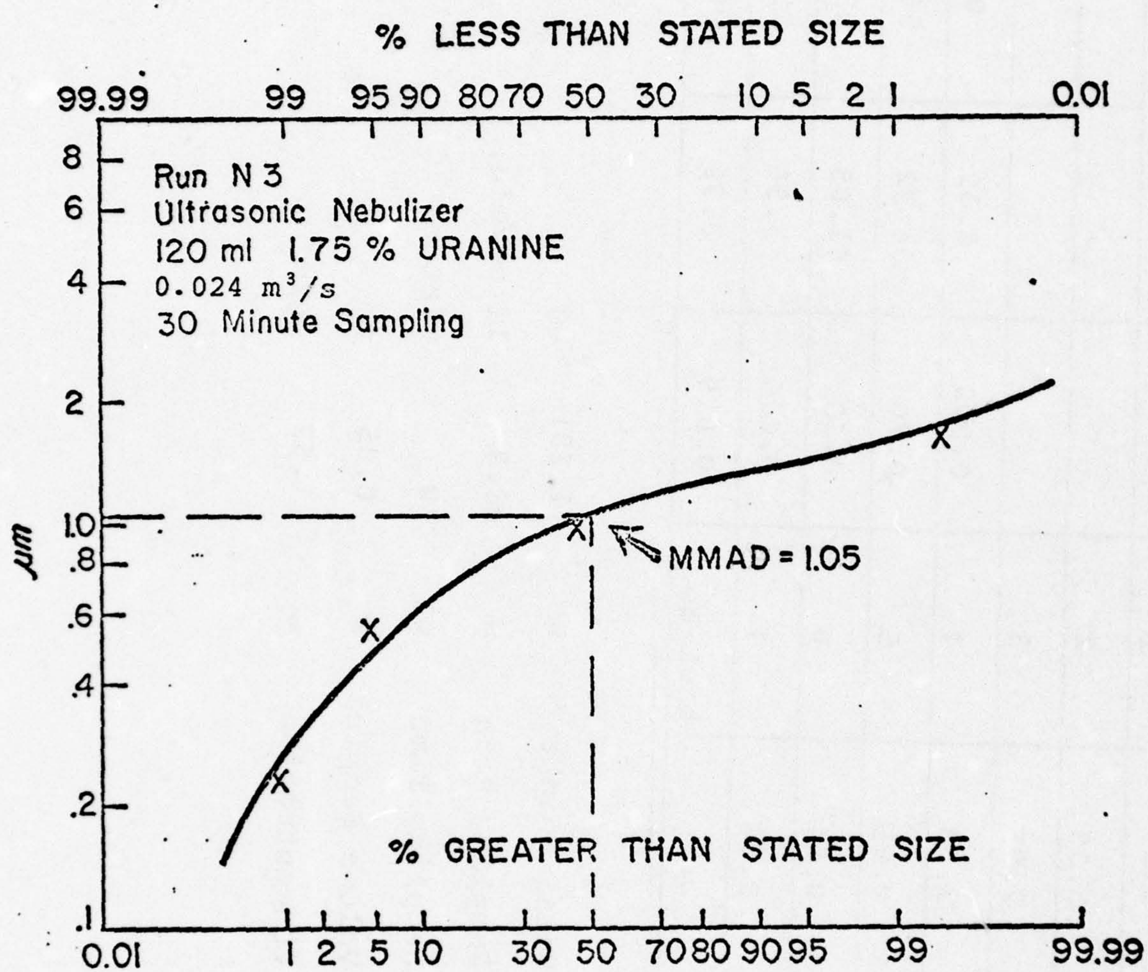
Total Weight = 1.291 mg

Sampling Rate = 28.3 liter/min.

Sampling Time = 30 minutes

Volume Sampled = 0.85 m^3

Concentration = 1.52 mg/m^3

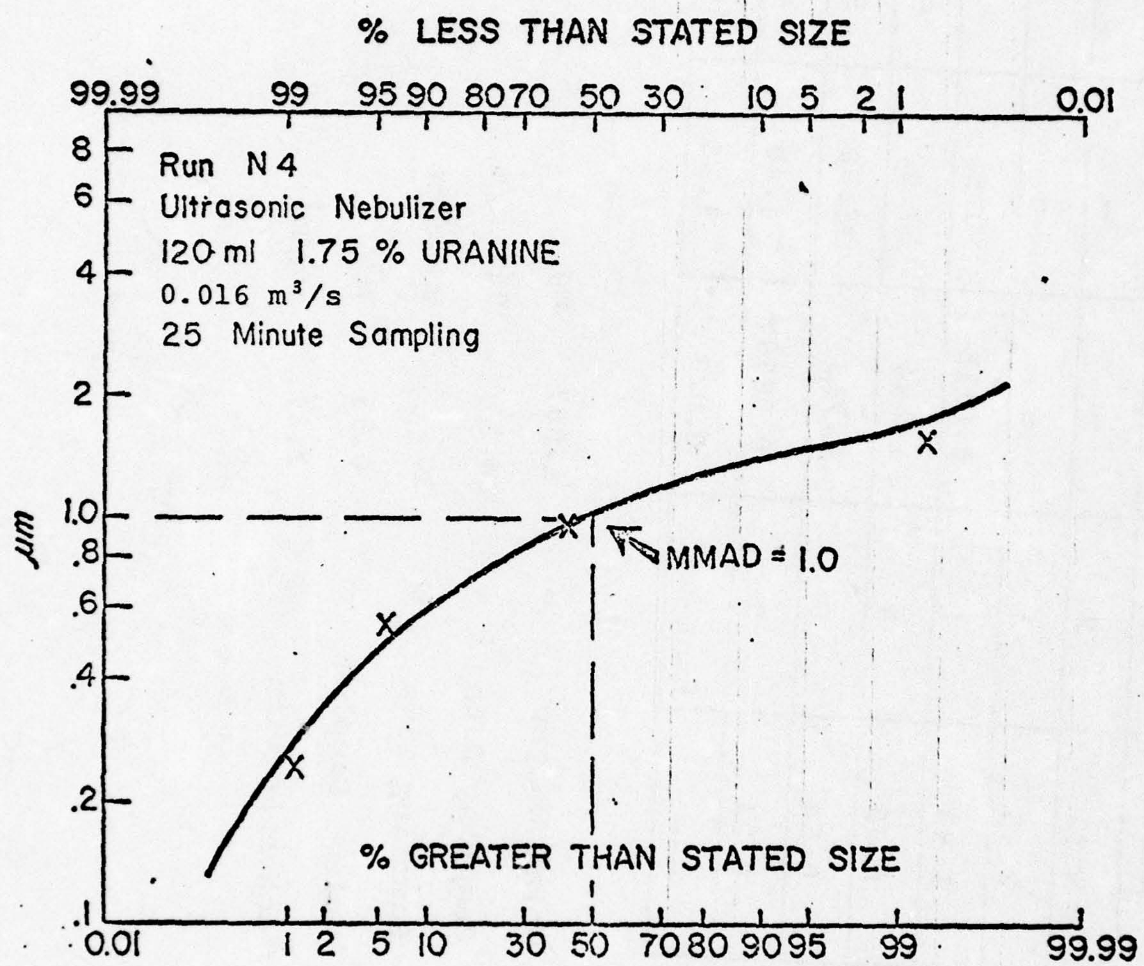

% LESS THAN STATED SIZE
Run N 3
Ultrasonic Nebulizer
120 ml 1.75 % URANINE
0.024 m³/s
30 Minute Sampling
MMAD = 1.05
μm
% GREATER THAN STATED SIZE

RUN N4

Andersen Sampler
Spectrophotometric Determination

Stage 50% point (μm)	Stage Number	Weight (mg)	% Weight	Cumulative % Weight
---	1	-	-	-
5.35	2	-	-	-
2.95	3	-	-	-
1.53	4	0.0115	0.58	0.58
0.95	5	1.150	57.88	58.46
0.54	6	0.715	35.98	94.44
0.24	7	0.0875	4.40	98.84
---	back-up	0.023	1.16	100.00

Total Weight	=	1.987	mg
Sampling Rate	=	28.3	liter/min.
Sampling Time	=	30	minutes
Volume Sampled	=	0.85	m^3
Concentration	=	2.34	mg/m^3


% LESS THAN STATED SIZE
99.99 99 95 90 80 70 50 30 10 5 2 1 0.01
Run N 4
Ultrasonic Nebulizer
120 ml 1.75 % URANINE
0.016 m³/s
25 Minute Sampling
8 6 4 2 1.0 .8 .6 .4 .2 .1
µm
MMAD = 1.0
% GREATER THAN STATED SIZE
0.01 1 2 5 10 30 50 70 80 90 95 99 99.99

Andersen Sampler
Spectrophotometric Determination

RUN N5

Stage 50% point (μm)	Stage Number	Weight (mg)	% Weight	Cumulative % Weight
---	1	-	-	-
5.35	2	-	-	-
2.95	3	-	-	-
1.53	4	0.0825	2.17	-
0.95	5	2.60	68.32	70.49
0.54	6	0.965	25.36	95.85
0.24	7	0.090	2.36	98.21
---	back-up	0.068	1.79	100.00

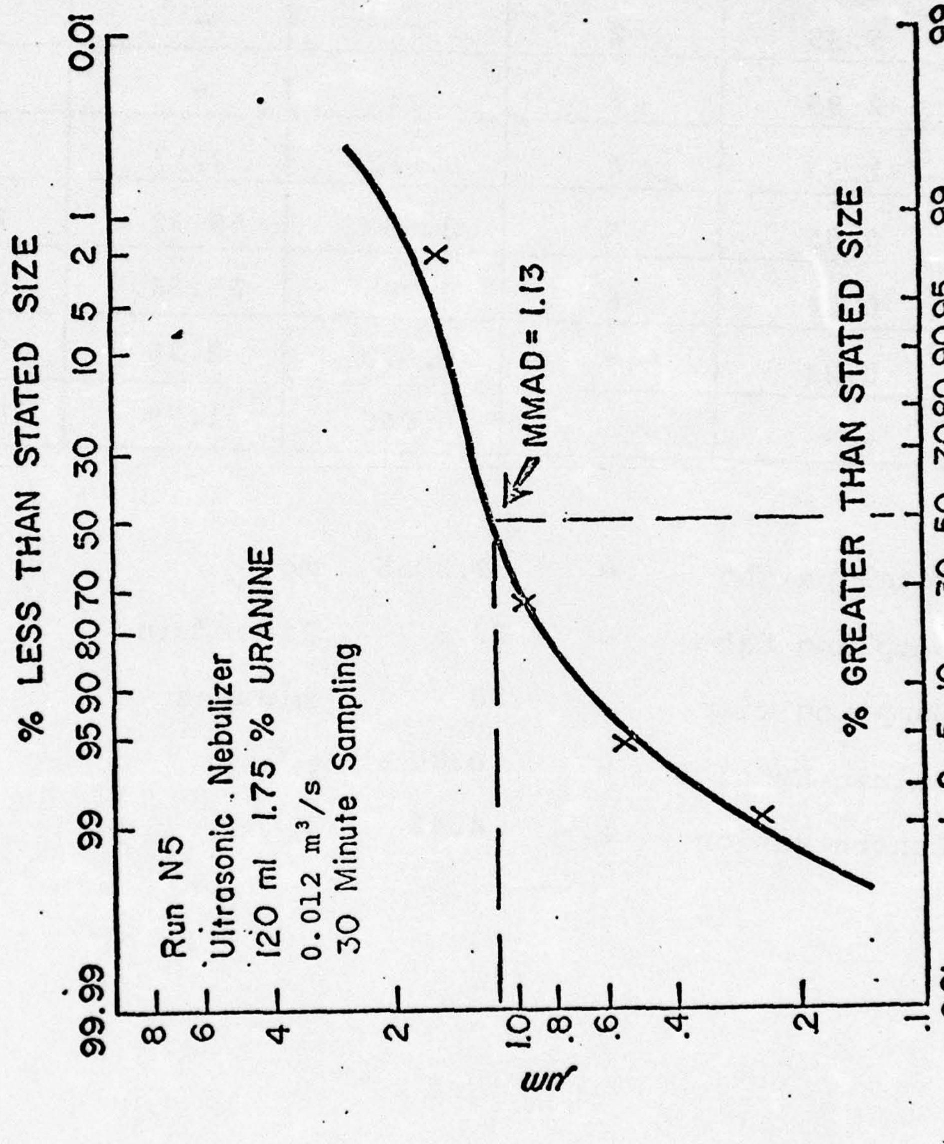
Total Weight = 3.8055 mg

Sampling Rate = 28.3 liter/min.

Sampling Time = 30 minutes

Volume Sampled = 0.85 m^3

Concentration = 4.48 mg/m^3



% LESS THAN STATED SIZE
99.99 99 95 90 80 70 50 30 10 5 2 1 0.01
Run N5
Ultrasonic Nebulizer
120 ml 1.75 % URANINE
0.012 m³/s
30 Minute Sampling
MMAD = 1.13
μm
8 6 4 2 1.0 .8 .6 .4 .2 .1
% GREATER THAN STATED SIZE
0.01 1 2 5 10 30 50 70 80 90 95 99 99.99

RUN W1 Upper Port, Andersen Sampler

Stage 50% point (μm)	Stage Number	Weight (mg)	% Weight	Cumulative % Weight
---	1	1.2	2.73	2.73
5.35	2	4.7	10.71	13.44
2.95	3	8.3	18.91	32.35
1.53	4	14.0	31.89	64.24
0.95	5	9.7	22.09	86.33
0.54	6	4.4	10.02	96.35
0.24	7	1.3	2.96	99.31
---	back-up	0.3	0.68	99.99

Total Weight	=	43.9	mg
Sampling Rate	=	28.3	liter/min.
Sampling Time	=	30	minutes
Volume Sampled	=	0.85	m^3
Concentration	=	51.7	mg/m^3

RUN W1 Lower Port, Andersen Sampler

Stage 50% point (μm)	Stage Number	Weight (mg)	% Weight	Cumulative % Weight
---	1	0.6	1.44	1.44
5.35	2	4.0	9.60	11.04
2.95	3	10.0	24.01	35.05
1.53	4	11.8	28.33	63.38
0.95	5	9.6	23.05	86.43
0.54	6	4.1	9.84	96.27
0.24	7	1.3	3.12	99.39
---	back-up	0.25	0.60	99.99

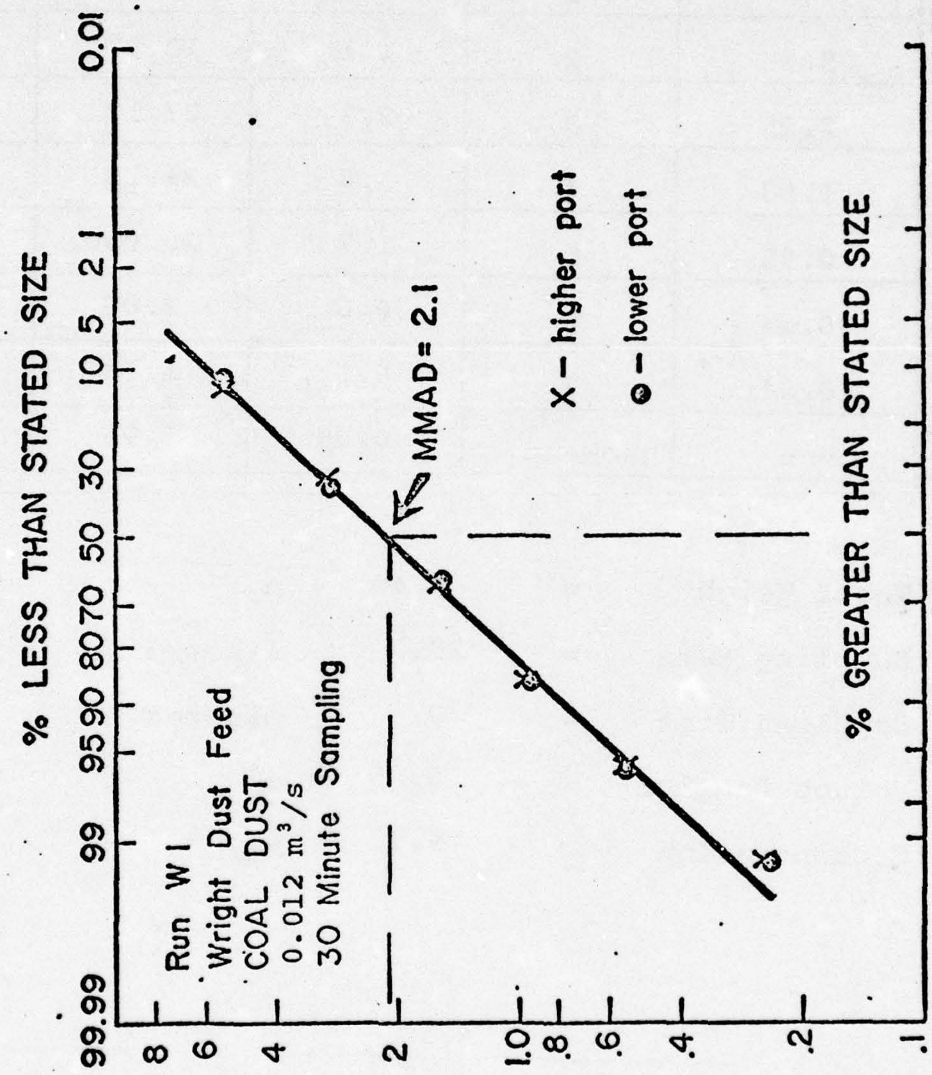
Total Weight = 41.65 mg

Sampling Rate = 28.3 liter/min.

Sampling Time = 30 minutes

Volume Sampled = 0.85 m^3

Concentration = 49.1 mg/m^3


% LESS THAN STATED SIZE
99.99 99 95 90 80 70 50 30 10 5 2 1 0.01
% GREATER THAN STATED SIZE
0.01 1 2 5 10 30 50 70 80 90 95 99 99.99
8 6 4 2 1.0 .8 .6 .4 .2 .1
Run W1
Wright Dust Feed
COAL DUST
0.012 m³/s
30 Minute Sampling
MMAD= 2.1
X – higher port
o – lower port

RUN W2 Andersen Sampler

Stage 50% point (μm)	Stage Number	Weight (mg)	% Weight	Cumulative % Weight
---	1	0.8	9.43	9.43
5.35	2	1.1	12.97	22.40
2.95	3	2.3	27.12	49.52
1.53	4	1.8	21.23	70.75
0.95	5	1.7	20.05	90.80
0.54	6	0.6	7.06	97.86
0.24	7	0.1	1.18	99.04
---	back-up	0.08	0.95	99.99

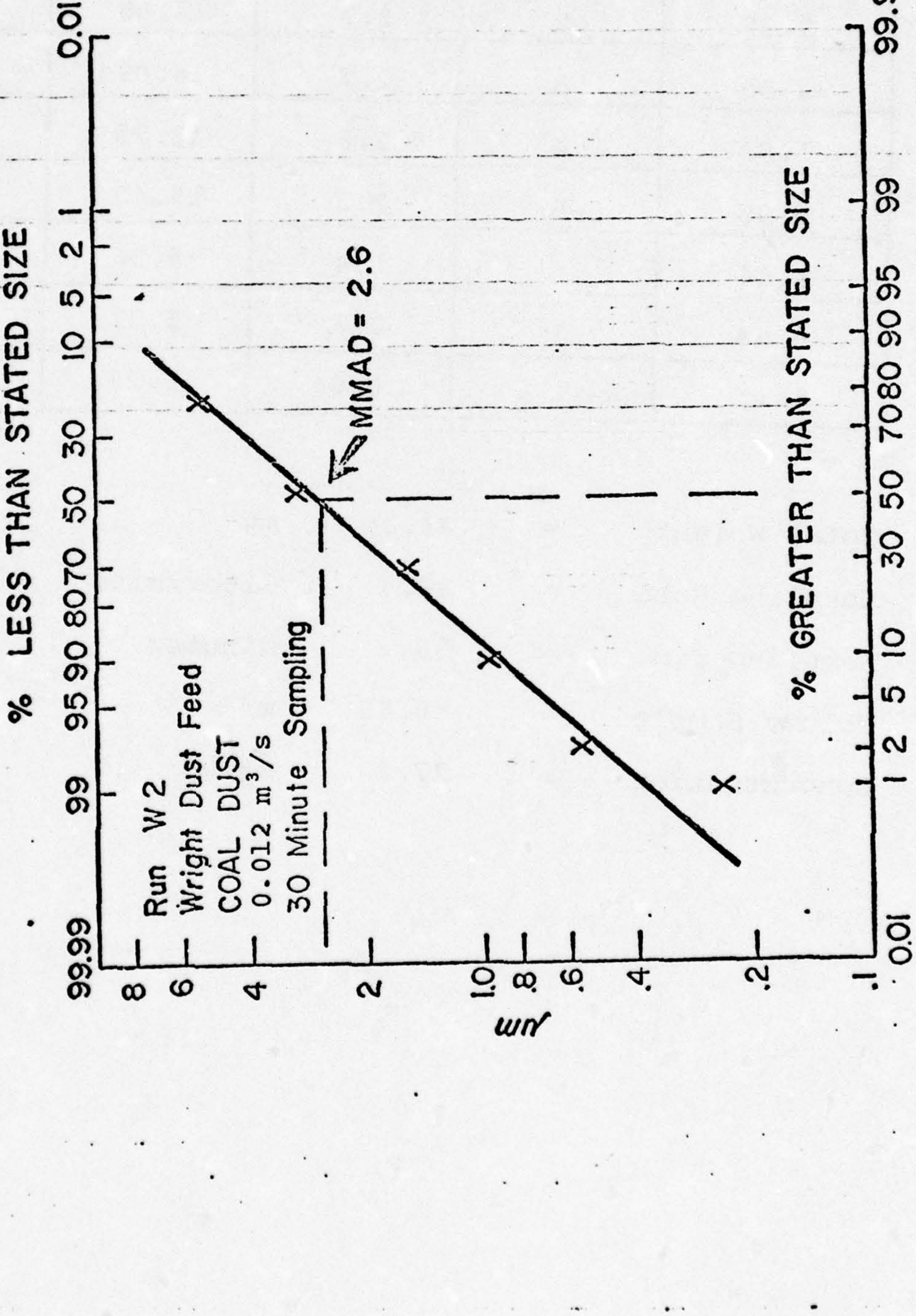
Total Weight = 8.49 mg

Sampling Rate = 28.3 liter/min.

Sampling Time = 30 minutes

Volume Sampled = 0.85 m^3

Concentration = 9.97 mg/m^3

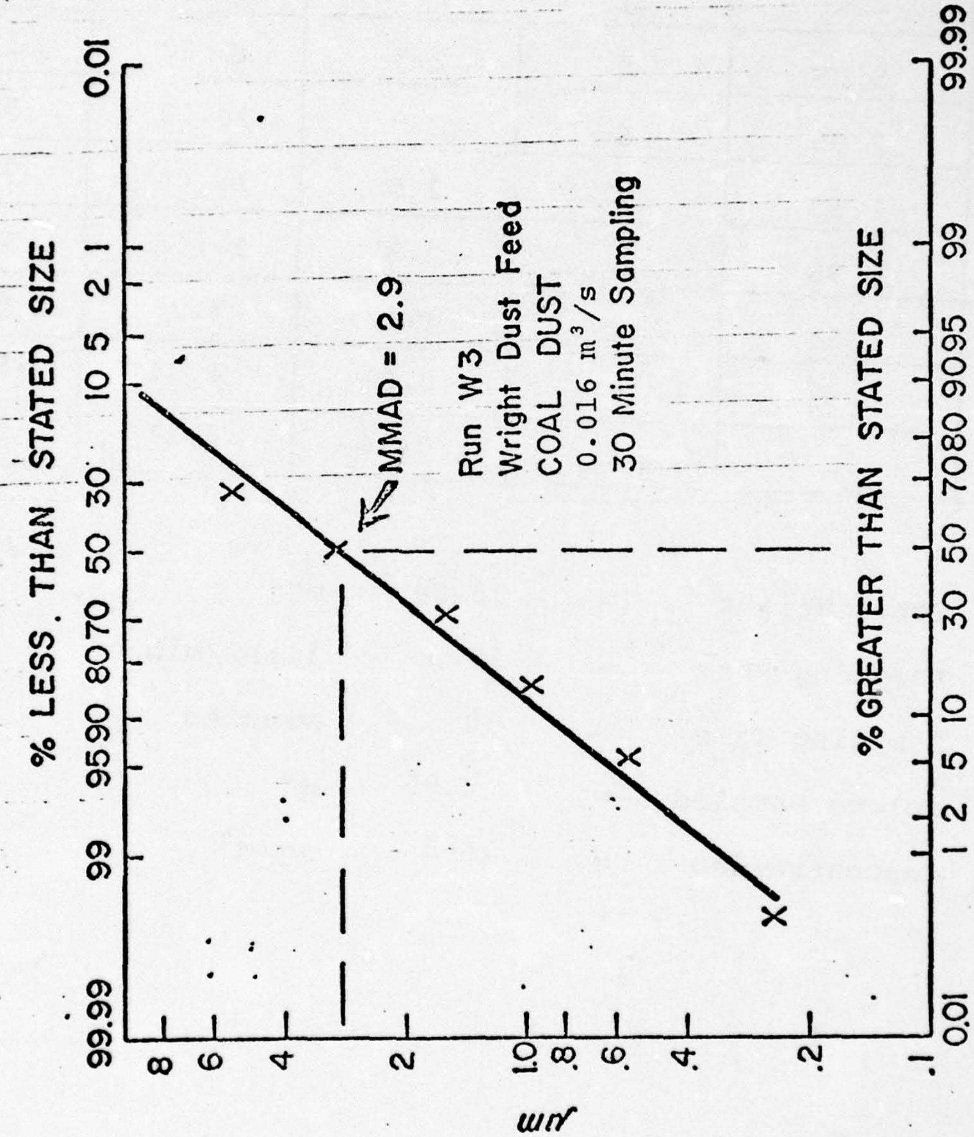


% LESS THAN STATED SIZE
% GREATER THAN STATED SIZE
MMAD = 2.6
Run W 2
Wright Dust Feed
COAL DUST
0.012 m³/s
30 Minute Sampling
µm

RUN W3 Andersen Sampler

Stage 50% point (μm)	Stage Number	Weight (mg)	% Weight	Cumulative % Weight
---	1	2.2	14.73	14.73
5.35	2	2.7	18.08	32.81
2.95	3	2.7	18.08	50.89
1.53	4	2.8	18.75	69.84
0.95	5	2.3	15.40	85.04
0.54	6	1.4	9.36	94.40
0.24	7	0.8	5.32	99.72
---	back-up	0.04	0.27	99.99

Total Weight	=	14.94	mg
Sampling Rate	=	28.3	liter/min.
Sampling Time	=	30	minutes
Volume Sampled	=	0.85	m^3
Concentration	=	17.2	mg/m^3


% LESS THAN STATED SIZE
0.01
2 1
10 5
30
50
80 70
95 90
99
99.99
MMAD = 2.9
Run W3
Wright Dust Feed
COAL DUST
0.016 m³/s
30 Minute Sampling
% GREATER THAN STATED SIZE
99.99
99
90 95
70 80
50
30
10
5
2
1
0.01
8
6
4
2
1.0
.8
.6
.4
.2
.1
µm

RUN W4 Andersen Sampler

Stage 50% point (μm)	Stage Number	Weight (mg)	% Weight	Cumulative % Weight
---	1	2.2	15.90	15.90
5.35	2	2.3	16.62	32.52
2.95	3	2.8	20.23	52.75
1.53	4	2.5	18.06	70.81
0.95	5	2.3	16.62	87.43
0.54	6	1.1	7.95	95.38
0.24	7	0.6	4.34	99.72
---	back-up	0.04	0.29	99.99

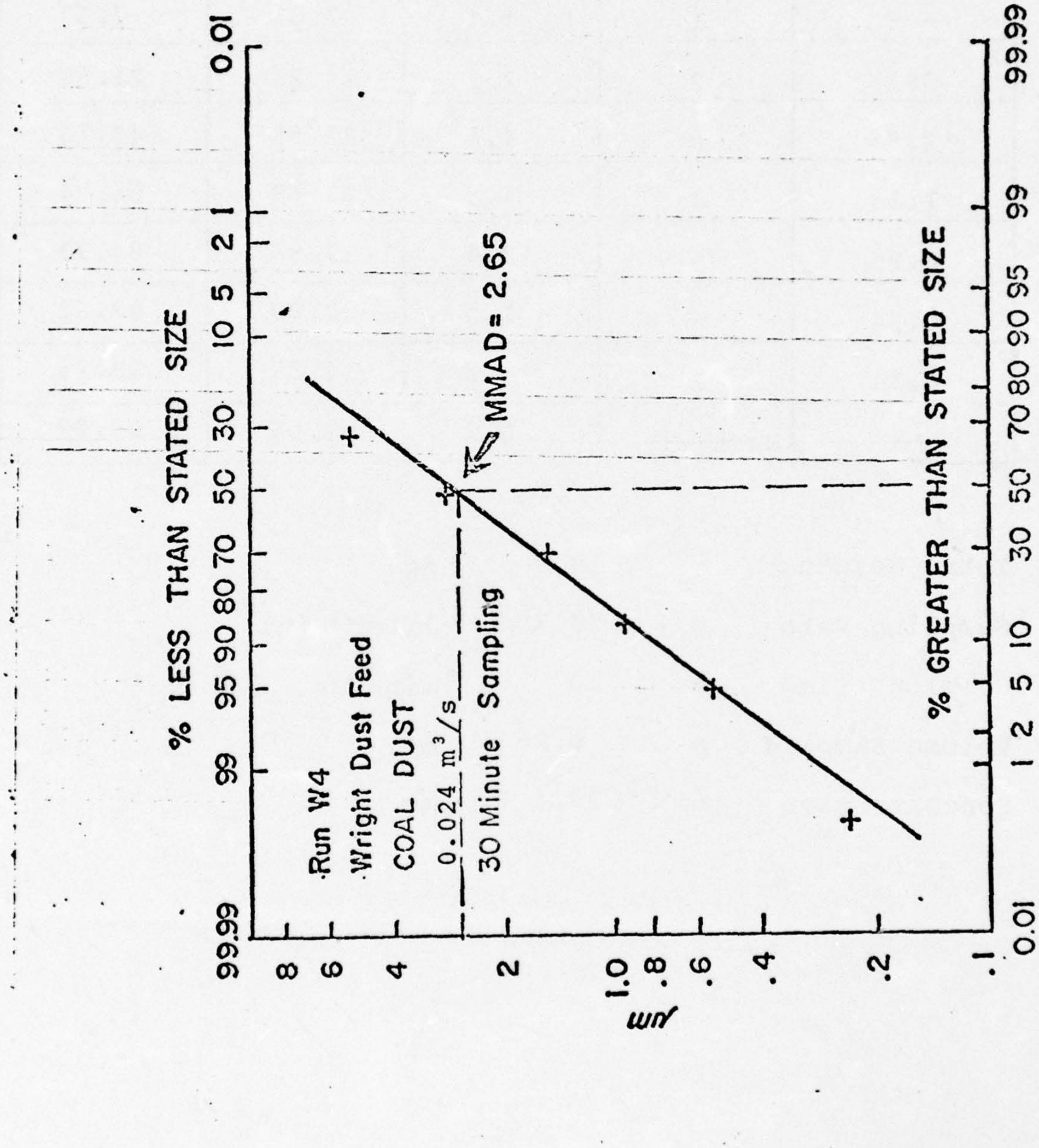
Total Weight = 13.84 mg

Sampling Rate = 28.3 liter/min.

Sampling Time = 30 minutes

Volume Sampled = 0.85 m^3

Concentration = 16.3 mg/m^3



% LESS THAN STATED SIZE
99.99 99 95 90 80 70 50 30 10 5 2 1 0.01
% GREATER THAN STATED SIZE
0.01 1 2 5 10 30 50 70 80 90 95 99 99.99
μm
8 6 4 2 1.0 .8 .6 .4 .2 .1
MMAD= 2.65
Run W4
Wright Dust Feed
COAL DUST
0.024 m³/s
30 Minute Sampling

RUN W5 Andersen Sampler

Stage 50% point (μm)	Stage Number	Weight (mg)	% Weight	Cumulative % Weight
---	1	1.4	7.37	7.37
5.35	2	2.7	14.21	21.58
2.95	3	4.1	21.58	43.16
1.53	4	4.5	23.68	66.84
0.95	5	3.4	17.89	84.73
0.54	6	1.5	7.89	92.62
0.24	7	1.2	6.32	98.94
---	back-up	0.2	1.05	99.99

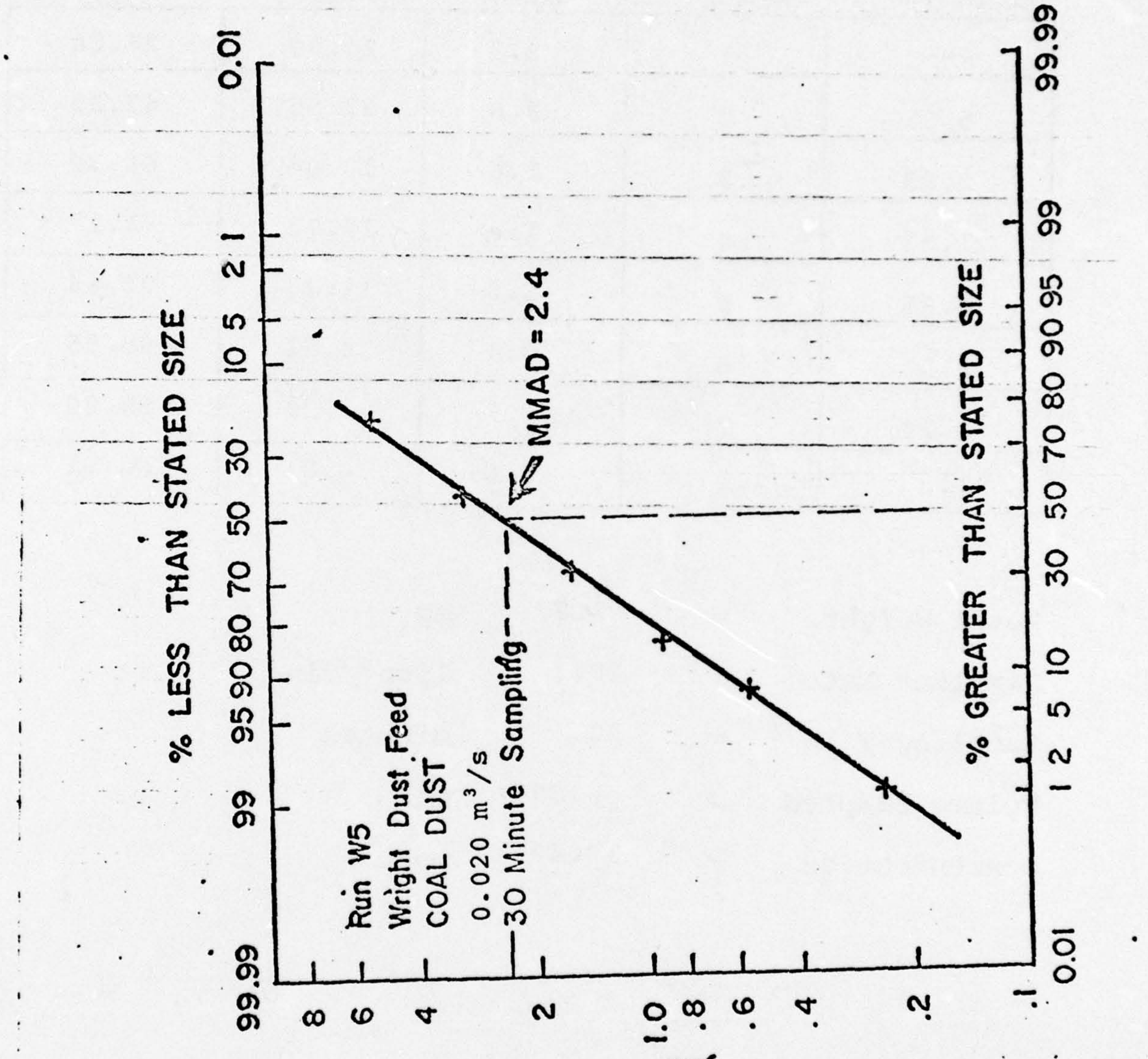
Total Weight = 19.0 mg

Sampling Rate = 28.3 liter/min.

Sampling Time = 30 minutes

Volume Sampled = 0.85 m^3

Concentration = 22.4 mg/m^3



% LESS THAN STATED SIZE
% GREATER THAN STATED SIZE
MMAD = 2.4
Run W5
Wright Dust Feed
COAL DUST
0.020 m³/s
30 Minute Sampling
μm
99.99
99
95 90 80 70 50 30 10 5 2 1
0.01
1 2 5 10 30 50 70 80 90 95
8
6
4
2
1.0
.8
.6
.4
.2
.1

RUN F2 Andersen Sampler

Stage 50% point (μm)	Stage Number	Weight (mg)	% Weight	Cumulative % Weight
---	1	2.2	24.80	24.80
5.35	2	2.0	22.55	47.35
2.95	3	1.6	18.04	65.39
1.53	4	1.4	15.78	81.17
0.95	5	1.0	11.27	92.44
0.54	6	0.4	4.51	96.95
0.24	7	0.2	2.25	99.20
---	back-up	0.07	0.81	100.01

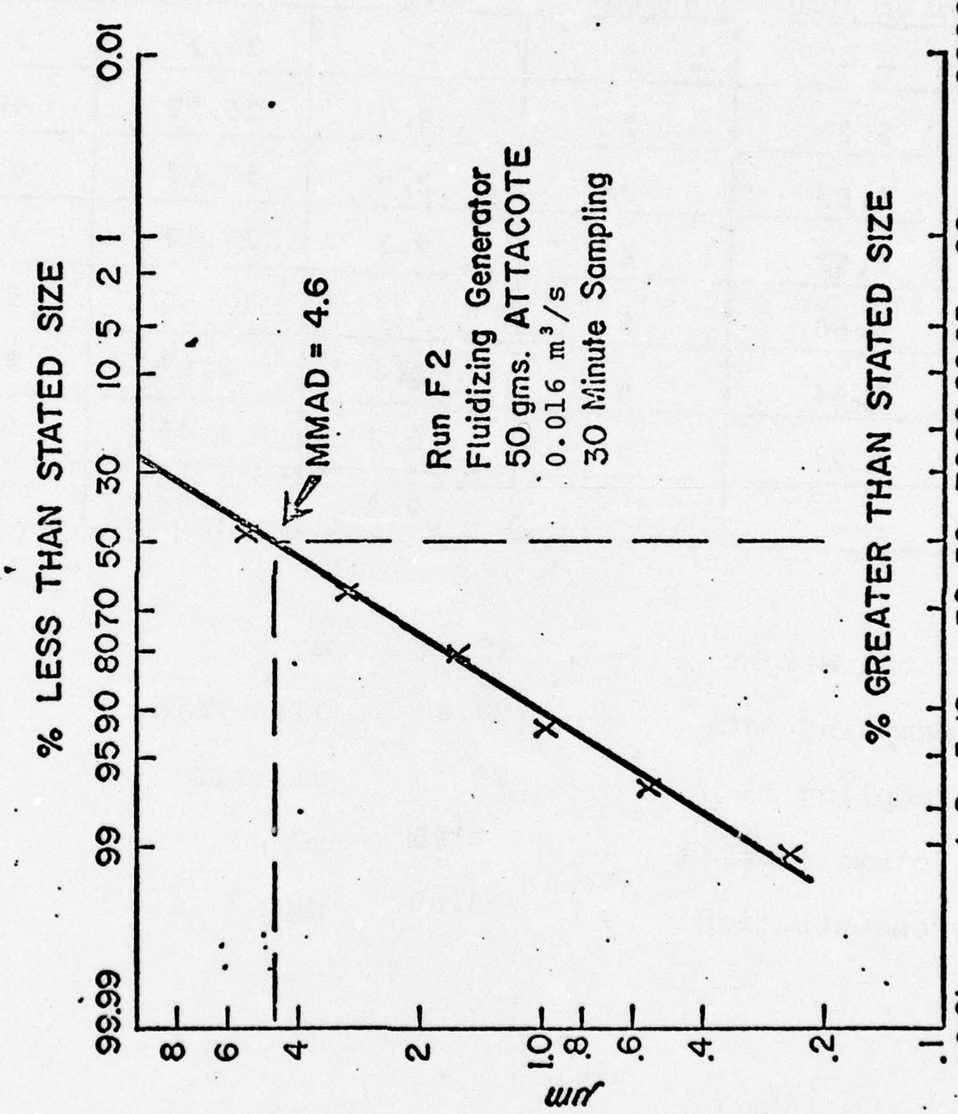
Total Weight = 8.87 mg

Sampling Rate = 28.3 liter/min.

Sampling Time = 30 minutes

Volume Sampled = 0.85 m^3

Concentration = 10.44 mg/m^3



% LESS THAN STATED SIZE
% GREATER THAN STATED SIZE
MMAD = 4.6
Run F 2
Fluidizing Generator
50 gms. ATTACOTE
$0.016\ m^3/s$
30 Minute Sampling
μm

RUN F3 Upper Port, Andersen Sampler

Stage 50% point (μm)	Stage Number	Weight (mg)	% Weight	Cumulative % Weight
---	1	3.6	26.77	26.77
5.35	2	2.7	20.07	46.84
2.95	3	2.5	18.57	65.43
1.53	4	2.3	17.10	82.53
0.95	5	1.6	11.90	94.43
0.54	6	0.4	2.97	97.40
0.24	7	0.2	1.49	98.89
---	back-up	0.15	1.12	100.01

Total Weight = 13.45 mg

Sampling Rate = 28.3 liter/min.

Sampling Time = 30 minutes

Volume Sampled = 0.85 m^3

Concentration = 15.80 mg/m^3

RUN F3 Lower Port, Andersen Sampler

Stage 50% point (μm)	Stage Number	Weight (mg)	% Weight	Cumulative % Weight
---	1	6.8	35.16	35.16
5.35	2	3.2	16.55	51.71
2.95	3	3.0	15.51	67.22
1.53	4	2.8	14.48	81.70
0.95	5	2.4	12.41	94.41
0.54	6	0.9	4.65	98.76
0.24	7	0.2	1.03	99.79
---	back-up	0.04	0.21	100.00

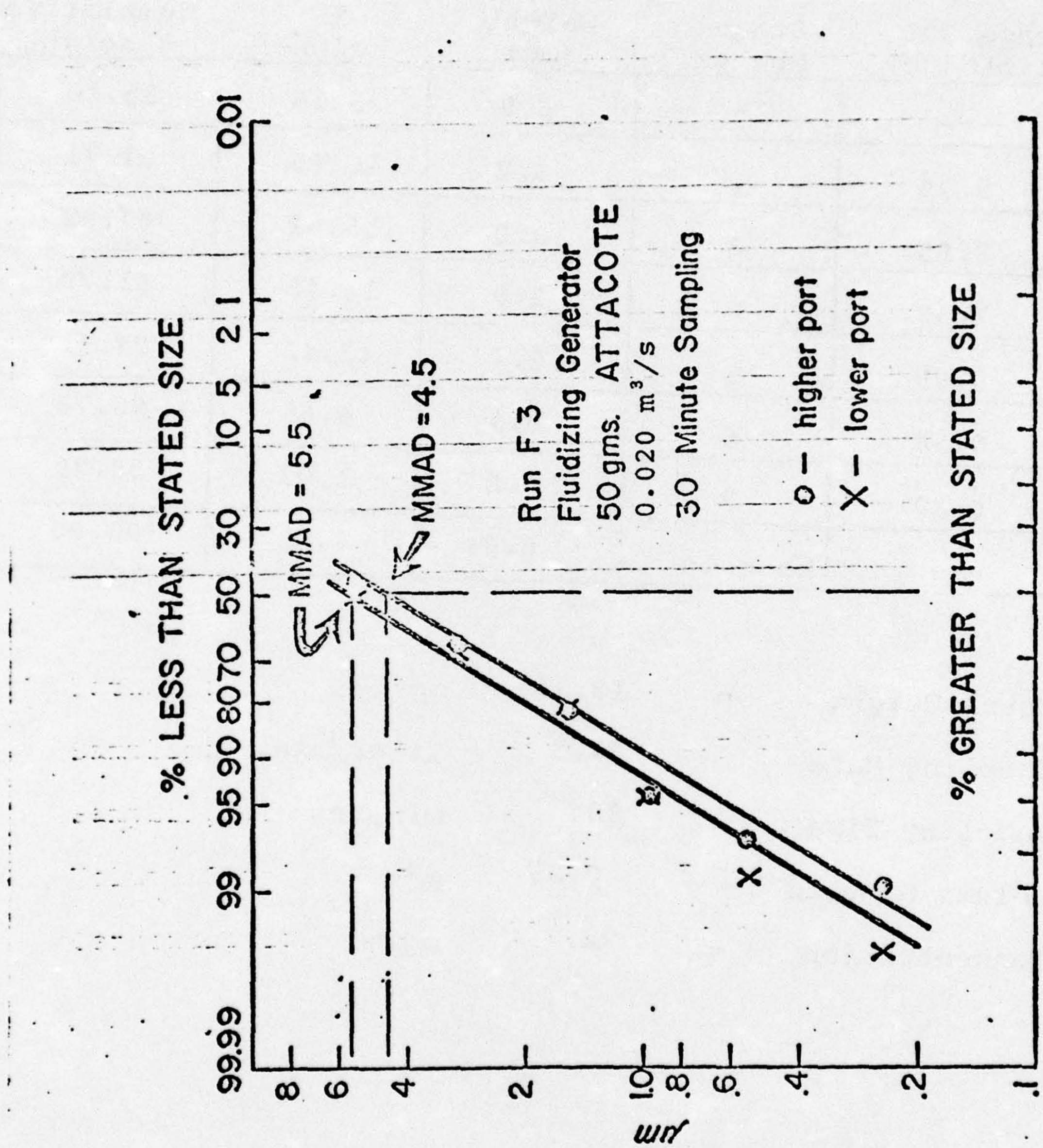
Total Weight = 19.34 mg

Sampling Rate = 28.3 liter/min.

Sampling Time = 30 minutes

Volume Sampled = 0.85 m^3

Concentration = 22.8 mg/m^3


% LESS THAN STATED SIZE
0.01
1
2
5
10
30
50
70
80
90
95
99
99.99
% GREATER THAN STATED SIZE
99.99
99
95
90
80
70
50
30
10
5
2
1
0.01
μm
8
6
4
2
1.0
.8
.6
.4
.2
.1
MMAD = 5.5
MMAD = 4.5
Run F 3
Fluidizing Generator
50 gms. ATTACOTE
0.020 m³/s
30 Minute Sampling
O – higher port
X – lower port

RUN F4 Upper Port, Andersen Sampler

Stage 50% point (μm)	Stage Number	Weight (mg)	% Weight	Cumulative % Weight
---	1	4.1	30.46	30.46
5.35	2	2.2	16.34	46.80
2.95	3	2.8	20.80	67.60
1.53	4	2.2	16.34	83.94
0.95	5	1.6	11.89	95.83
0.54	6	0.4	2.97	98.80
0.24	7	0.1	0.74	99.54
---	back-up	0.06	0.45	99.99

Total Weight	=	13.46	mg
Sampling Rate	=	28.3	liter/min.
Sampling Time	=	30	minutes
Volume Sampled	=	0.85	m^3
Concentration	=	15.83	mg/m^3

RUN F4 Lower Port, Andersen Sampler

Stage 50% point (μm)	Stage Number	Weight (mg)	% Weight	Cumulative % Weight
---	1	7.5	47.37	47.37
5.35	2	2.8	17.69	65.06
2.95	3	2.1	13.27	78.33
1.53	4	1.8	11.37	89.70
0.95	5	1.1	6.95	96.65
0.54	6	0.4	2.53	99.18
0.24	7	0.1	0.63	99.81
---	back-up	0.03	0.19	100.00

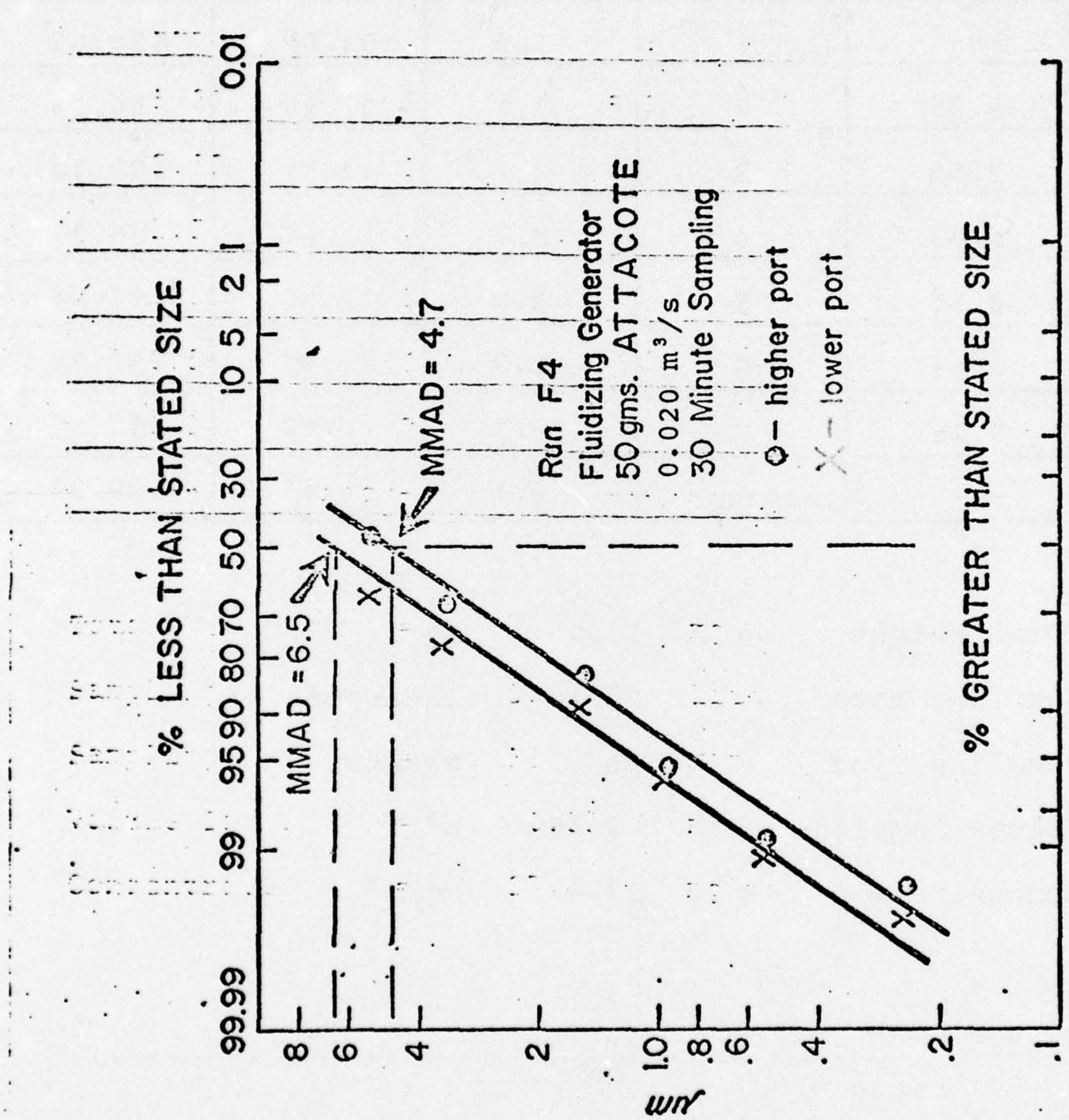
Total Weight = 15.83 mg

Sampling Rate = 28.3 liter/min.

Sampling Time = 30 minutes

Volume Sampled = 0.85 m^3

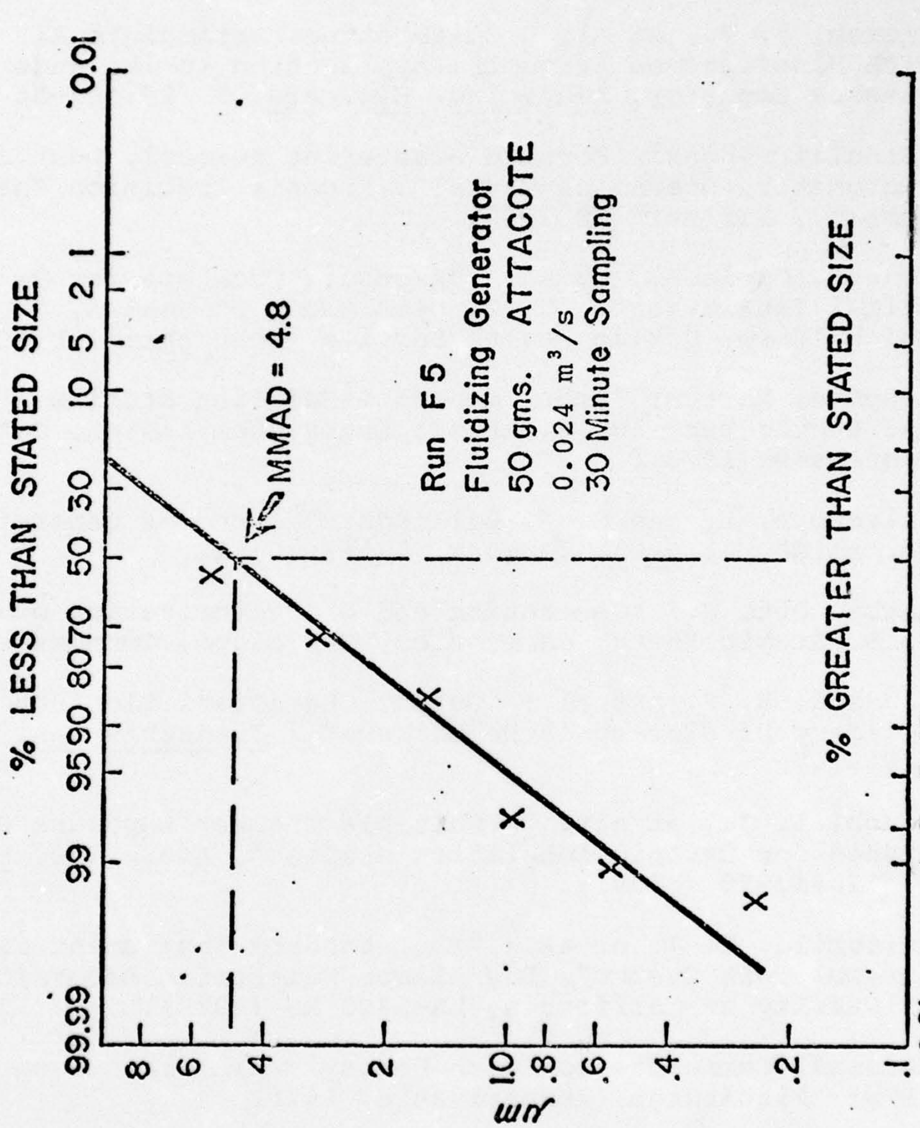
Concentration = 18.62 mg/m^3


% LESS THAN STATED SIZE
99.99 99 95 90 80 70 50 30 10 5 2 1 0.01
% GREATER THAN STATED SIZE
0.01 1 2 5 10 30 50 70 80 90 95 99 99.99
μm
8 6 4 2 1.0 .8 .6 .4 .2 .1
MMAD = 6.5
MMAD = 4.7
Run F4
Fluidizing Generator
50 gms. ATTACOTE
0.020 m³/s
30 Minute Sampling
O – higher port
X – lower port

RUN F5 Upper Port, Andersen Sampler

Stage 50% point (μm)	Stage Number	Weight (mg)	% Weight	Cumulative % Weight
---	1	7.9	34.05	34.05
5.35	2	5.1	21.98	56.03
2.95	3	4.1	17.67	73.70
1.53	4	2.7	11.64	85.34
0.95	5	2.9	12.50	97.84
0.54	6	0.3	12.99	99.13
0.24	7	0.1	0.43	99.56
---	back-up	0.1	0.43	99.99

Total Weight	=	23.2	mg
Sampling Rate	=	28.3	liter/min.
Sampling Time	=	30	minutes
Volume Sampled	=	0.85	m^3
Concentration	=	27.4	mg/m^3


% LESS THAN STATED SIZE
% GREATER THAN STATED SIZE
MMAD = 4.8
Run F5
Fluidizing Generator
50 gms. ATTACOTE
0.024 m³/s
30 Minute Sampling
μm

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